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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Analytical Quality Circles

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FOREWORD

Analytical means to capture numerical figures, to examine data, to process arithmetically, to detect tendencies by use of graphs, diagrams, etc., and based on the so processed facts, to grasp the crux of a problem, to find a remedy, and to implement a solution. This approach by all levels of managers, supervisors, and workers is necessary to vitalize a company by creating a constantly self-improving manufacturing system.

'The obligation to improve the system never ceases (W. Edwards Deming)." The latter is more a reality than a slogan. Intense competition requires constant resolution of problems and constant identification of the next problems to be solved. Thus, constant methods development, i.e., constant change, is the only true reality for survival in the modem industrial world.

Effective quality circles are analytical in nature. Where they are armed with analytical methods and given knowledge of how work processes are performing, even workers methodically analyze and make suggestions for improvements. Thus, no one should read this publication without studying Appendix D. Appendix D consists entirely of worker accounts which detail actual accomplishments by quality circles in shipyards operated by Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI). The worker prepared Pareto, Cause and Effect, and other analytical charts are especially noteworthy. Appendix D cuts through the misleading verbiage that surrounds quality circles and other such programs that are based on little more than slogans and exhortations.

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The material on which the contents are based was compiled by a team for which overall management was provided by IHI Marine Technology, Inc. (WIT), New York City. Y. Kido, Deputy Senior Manager, IHI International, Kure Marine Consulting Division, is the principal author. He was assisted by T. Sueyasu of IHI's Aioi Shipyard and A. Hidaka of IHI's Kure Shipyard. Y. Ichinose, former President, IMT, was the Project Manager and performed the translation into English. Y. Okayama, Deputy Senior Manager, IHI International Division, Tokyo, served as an advisor. Editing and some supplemental writing was performed by L.D. Chirillo and R.D. Chirillo.

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EX SCIENTIA EFFICIENS

Quality Control shoud check the process, not the product.

W. Edwards Deming

1.0 INTRODUCTION

The abbreviation "TQC" stands for *Total Quality Control,* a largely Japanese outgrowth of the worldwide quality control movement.

To many people, Quality Control (QC) originally meant no more than testing to check the quality of finished goods. Later, statistical techniques (statistical quality control methods) were introduced. More recently, TQC was developed, because with the automated processes and high technology used today, it is difficult for a small group of specialists or inspectors alone to control the quality of a final product.

Before, QC affected things that could be measured and weighed, e.g., ships, engines and their parts. Today, we have come to realize that the quality of work, too, can be controlled, and so QC is now used in the fields of management, sales, and service.

Even in the most ultramodern highly-mechanized works, people are needed to design, manufacture and sell products that customers require. That is why people are one of the key factors in planning and execution of a TQC Movement. In Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI) there is a policy to constantly improve the quality of products and services, but that is not all. Most of all, TQC activities are aimed at helping the people who play the most fundamental roles in the company's business.

1.1 *History of Small Group Activity in Japan*

In Japan, organized activities by groups formed in workplaces are being used more and more to control work and bring improvements. These groups have many different names: "Quality Control Circles" (QCCs), "Zero Defect Movement;' "Self-Control Activities;' "Thinking Group Activities;' "Shop Group Activities." Whatever their particular names, what they do is basically the same.

The activities of this sort now taking place in Japan fall into two broad categories. The first includes the activities of Quality Control Circles (QCCs), and the second is the Zero Defect (ZD) Movement introduced from the United States. Most Japanese group activities are the result of the introduction and development of one or the other of these two types of program.'

After the World War II, statistical methods for quality control were introduced to Japan mainly from the U.S.A. In 1950, Dr. W. E. Deming started seminars for Statistical Quality Control (SQC) which used check sheets, random sampling, experimental planning, etc. and in 1951, the Deming Prize and the Deming Application Prize were established. These Prizes stimulated many Japanese managers and engineers to promote SQC and, as a result, provide great benefits to industry in the form of increased profits.

In 1954, Dr. J. M. Juran, a managerial consultant in the U. S.A., came to Japan and emphasized to many groups of Japanese managers and engineers that quality control was an integral part of management, and that it had to be practiced in the total context of improvement management. His influence contributed to the emergence of a wider concept of quality control.

In April 1962, the first issue of *Quality Control for Foreman* (Genba to QC) was published by the Union of Japanese Scientists and Engineers (JUSE) for the purpose of instructing and enlightening first-line supervisors in the techniques of quality control. The idea of promoting quality control more closely linked to the needs of the shop floor, led to the formation of groups for studying the magazine together. These study groups were called Quality Control Circles (QCCS).

Later, companywide efforts were made to promote QCCS and firmly entrench them in shop-floor practice. These efforts resulted in QC activities which adapted very well with shop floor customs and practices, and produced the extremely effective QC system seen in Japan today. This QC system, because of its pervasiveness is TQC.

As TQC has come to affect everyone in the company, from the man on the shop floor to business managers and executives, some people use the term *Company-Wide Quality Control.*

IZD was based on the idea that prescribed quality for a product could only be ensured by performing each of the operations constituting the manufacturing process with no mistakes or deviations.

1.2 *History of TQC in IHI*

In IHI, quality circle activities were introduced, step by step during a period of some ten years, by a company-wide quality control movement involving all of the company's plants which produce industrial, marine, and aviation equipment and machinery. The movement has slowly, but steadily, achieved tangible improvements toward targets that were set.

Each IHI plant implemented this movement in a way which most suited its particular circumstances as indicated in Figure 1-1 which shows how each plant designated its TQC movement. Targets and slogans were inspired by common principles. On the other hand, the variety found in their designations attests to the wide range of backgrounds on which the TQC movement was successfully implemented.

In IHI, one of the first formal steps toward QC implementation was the ZD movement which took the form of an organized suggestion system enlisting the participation of all employees who were enrolled in small groups in shops and offices. Targets were set for systematic elimination of hazards and defects from work environments, products, and services. Enhanced safety, manifested by fewer accidents, freed workers from fear and management from disbursement of expenses related to accidents. Safety in work is a target that none oppose and does not fail to win the support and backing of both management and labor.

After some time, when all personnel came to participate in the safety movement, IHI's shipyard management shifted the target of the movement to enhancement of productivity. At first, however, movement activities were not based on scientific approaches and principles.

From 1978 to 1979, many employees of various organizations, such as design, production, production control, and administration, were assigned to take part in seminars on quality control organized by the Union of Japanese Scientists & Engineers (JUSE). This marked the starting point in IHI's shipyards for properly organized quality control promotion which ultimately led to the present TQC movement.

WORKS	DESIGNATION OF MOVEMENT	INTENT OF DESIGNATION	SLOGAN
TOKYO SHIPYARD TOKYO TURBO-MACHINERY WORKS	TAT	THINK AND ACT FOR TOMORROW	FOREWARDNESS, CONFIDENCE, CREATION
TANASHI AEROENGINE PLANT MIZUHO AEROENGINE PLANT	SHINRAI	RELIANCE	HUMAN RELATIONS BASED ON MUTUAL RELIANCE SMILING FACES AT WORK; FAULT-FREE JOBS DONE; SATISFIED CUSTOMERS
YOKOHAMA NUCLEAR & CHEMICAL COMPONENT WORKS	SHOSHUDAN	SMALL GROUP ACTIVITIES	BID TO TWO-FOLD EFFICIENCY
YOKOHAMA MACHINERY WORKS	CP	CHALLENGE TO PERFECTION	CHALLENGE TO PERFECTION
AICHI MARINE STRUCTURE & MODULE WORKS	3A	ANZEN (SAFE) AKARUI (ENLIGHTENED) AICHI WORKS	TO ACT FORWARDLY AS AN INDIVIDUAL TO BUILD MUTUAL-CONFIDENCE BETWEEN MEMBERS TO DISPLAY LEADERSHIP IN ORGANIZATION
AIOI SHIPYARD AIOI DIESEL ENGINE WORKS AIOI BOILER WORKS	TQC	TOTAL QUALITY CONTROL	TO BUILDUP A STRONG WORKS TO WIN IN THE WORLD-WIDE COMPETITION WITH OTHER ENTERPRISES
KURE SHIPYARD	3Z	ZERO ACCIDENT ZERO DEFFECT ZERO LOSS	TO PERFORM PERFECT ENGINEERING TO REFINE NECESSARY TECHNIQUES
KURE AERO-ENGINE & TURBO MACHINERY PLANT	ZA	ZERO ANOMALY	TO BUILD A HAPPY AND BRIGHT WORKSHOP TO DO ZERO-ANOMALY JOB
KURE SHINGU STEEL STRUCTURE WORKS	SC	SELF CONTROL	FORWARDNESS CONTROL AND APPLICATION OF QC TECHNIQUES

2,300 QC circles
17,300 QC circle members
100,000 suggestions submitted every year

FIGURE 1-1: Different Movements Adopted for QC Promotion in Various IHI Plants and Works.

2.0 CONCEPT OF TQC MOVEMENT

2.1 *TQC Movement*

Total in the term *Total Quality Control* (TQC) means company-wide participation in the movement from top management to all employees. TQC also signifies all-encompassing application to all products, including interim products and all matters such as safety, quality, productivity, costs, and sales. TQC also includes broad quality of services, information, processes, workers, management, systems, the company, etc.

There are two basic TQC goals:

- Improvement of Company Structure
- Growth in Employee Vitality

2.1.1 *Improvement of Company Structure*

The first principle for improvement is *providing the products that customers want.*

It is important for a company to know exactly what customers want. Even if it is difficult for all employees to know this directly, customers' requirements should become evident as work leaves preparatory stages and comes into the working spheres of people downstream. From management to after sales service, it is everyone's job to "build in" quality stage by stage.

Safety is particularly important. The loss of life is to be prevented because of the grief caused. Secondly, it leads to payment of large sums in compensation for damages and could ruin a company's reputation, even putting its very existence in jeopardy.

For products to be safe, inexpensive and of high quality, every worker must imagine that the process being carried out, is the last in the production line before delivery to a customer instead of to a worker at the next stage. Not only machine operators, but offi ce workers and engineers as well, must adopt the same attitude with respect to their work. This implies that:

> At every level, people must have a clear understanding of the meaning and importance of quality control, have a concrete idea about what quality means in their particular scope of work, participate in ensuring required quality, and bear responsibilities involved in their assigned work.
>
> They must give the highest priority to quality when performing their work, without neglecting other factors, such as cost and scheduled delivery dates.
>
> They must also apply every possible effort to use and apply control techniques that promise to lead to further improvements.

The second principle is *expanding participation in management.*

Most people tend to think of management as the work of the company president and a few upper-level executives, i.e., something that has nothing to do with ordinary employees.

Each company has, or should have, a basic management policy which is used to determine specific directions that it will take in business affairs. Such policy has ramifications at all levels, e.g., works, departments, shops, and individuals. In the course of a company policy being broken down and applied as specific decisions, people cooperate with each other, persuade each other, and make decisions by common consent before the policy is implemented on the production floor. People who take part in this process are participating in management! There are certain aspects that make TQC effective:

- *Understanding and implementing management policy*
  As implementation of company policy gets increasingly specific, individuals and groups have to have an adequate understanding of the policies and goals of at least their immediate superiors. On this basis, they will have a grasp of targets and work to meet them.

- *Sharing roles.*
  To make a product, work must be divided. Only through the division of work and its responsible execution by each individual can the company operate smoothly.

- *Uniting for strength.*
  If you bind three arrows together, they cannot be easily broken. It is important that members of groups and organizations unite their strengths for a common target, whale simultaneously using their individual abilities to the maximum extent.

- *Encouraging efficient work.*
  The three basic factors in company activities are people, things and money. But how to use things and money economically and effectively to enable a company to make a profit, is something that each worker should think about as work is performed.

2.1.2 *Growth in Employee Vitality*

The roots on which a company can grow and fulfill its social responsibility lie in the people that work for it. That is why we often say, "A company is its people." The most basic need of a company is to have employees who are active, who constantly find a purpose in life and, concurrently, in their jobs.

As people's faces are different, so are their characters. While their feelings and behavior have certain points in common, they have different personalities that can be exchanged with nobody and, without which, there would be nobody. Respect for others comes from understanding people, knowing what tickles and inspires them effectively. When people are treated with respect, and when motivated to act as individuals to the maximum extent, an animated workplace is created.

What is important for an employee is that the company is assured of a healthy profit, that it provides a place to work in security and health, and that it should allow untrammeled development of each individual's potential. Such circumtances, however, are dependent on many factors including the work of the employees themselves. What is important is that individual employees contribute to creating such circumstances. There is no limit to the creative work that can be undertaken, and hence no limit to the target one can find in life.

A workplace, where these principles of human behavior are understood, where constant orientation and encouragement are provided, and where an orderly and stimulating environment prevails, is a workplace that accords to people all the respect they deserve. Objectives include:

- *Developing Personal Ability* — The TQC Movement includes attempts by individuals to exploit all their abilities to the fullest, by groups through mutual encouragement, to develop and express hidden abilities.

. *Fostering Free Expression* — This means making the workplace a forum where constructive opinions are freely expressed and where individual abilities are fully brought out. Fostering an atmosphere of free and frank expression is an important job of leaders and supervisors.

A person convinced of the purpose of what is being done, will do it willingly. Participation in determining directions and goals fosters a willingness to perform work.

Self-management means developing one's personality so as to be able to regulate one's attitudes and behavior purposefully, and it means doing one's job efficiently, whether or not, one is being closely directed or watched. It means using one's abilities unsparingly.

Thus basic goals of the TQC movement are:

. providing the products customers want,

. expanding participation in management,

- respecting people as people, and

. developing self-management.

2.2 *Quality Control Circle Activities*

QC is a system for producing, at minimum cost, products of quality that satisfy the clients' demands or needs. QC is what is known as "Statistical Quality Control" for the statistical approach adopted in its implementation. (The above definition is cited from the Japan Industrial Standard JIS Z 8101)

A QC circle (QCC) is a small group that autonomously performs QC activities to cover the production operations of the shop or office to which the group belongs.

This small group, with the active participation of all members, undertakes on a sustained and uninterrupted basis, and as a part of company-wide QC activities, autonomously initiated and mutually incited development of QC techniques, their implementation and improvement. (Cited from General Principles of the QC Circle published by the Union of Japanese Scientists and Engineers)

The basic concept of QCC activities, implemented as a company-wide movement, aims to:

. contribute to strengthening the ties between constituents (employees) of the company and, thereby, to further development of the company,

- to create working environments wherein each worker is accorded a due share of respect, and

- to draw out the potential capabilities that may lie dormant in employees to let them display their abilities to the fullest extent (Cited from General Principles for QC Circles Published by the Union of Japanese Scientists and Engineers).

The basic procedure for maintaining and continuously enhancing QCC activity is what is known as Deming's Control Circle; Plan, Do, Check and Action (PDCA).

2.2.1 *Constituting the QC Circle*

QCCS are highly dependent upon a modem product organization which features groups of workers organized along product lines, i.e., in production lines which match product categories and which are subdivided into distinct work stages. Shipbuilders in Japan adopted a product work breakdown in the early 1960s. As described in this publication, the effectiveness of QCCS in IHI's shipyards was greatly enhanced by the product-oriented worker groups that were formed as a result of the change to product organization. The identification of a QCC with a specific product (interim product) line and the responsibility of a group for a specific work process gives QCCS a depth and dimension unobtainable in a shipyard which is organized by traditional functional systems.

QCCS are, in principle, constituted of people who work in the same workplace. The best size for a circle to be able to function as a unit is between five and ten members, and certainly not more than fifteen.

In Japan, the smallest organizational units in a company are usually the work teams that are natural in a product work breakdown. Thus, the most common practice is to constitute group activities by units of such work teams.

Lately, more than one group has worked together (multi-group activities) when the subject being studied involved processes upstream and downstream in a production line. In time, the formation of project groups composed of all the people involved in related work across the organization is likely to occur.

2.2.2 *Selecting the Leader*

As soon as a group is formed, a leader must be chosen. Group activities are pursued free from outside intervention, and how the group is run is left entirely to the collective will of the members. The activities of a group will then be strongly influenced by its leader's talent.

The leader can be chosen in one of the following ways:

- When a group is newly formed, a workshop supervisor such as a foreman or assistant foreman serves as a leader.
- As a group's activities advance and get more specific, the senior worker could become the leader.
- As a group matures, a leader might be elected by its members.

2.2..3 The *Leaders Role*

The leader must *unite the* group by always considering matters from the standpoint of the whole group. This means:

- Trying to build good interpersonal relations among the members of the group. The members must be on good terms with each other.
- Encouraging everyone to participate in group activities, to speak out during meetings, and to take a specific role in the group.
- Insuring that all members cooperate.

The group must properly *orient* itself. Its purpose is not merely to fraternize. It must pick out specific problems affecting the workplace, and try to solve them. For this, the leader must:

- Pick out problems for study as group topics and set forth clear goals.
- Plan the steps toward problem solution.
- Let all members know the goals and substance of the planned activities and have members assume roles suited to their abilities.
- Afterwards, have all members reflect on and evaluate results obtained.

The key to getting together and to orienting a group's aspiration toward a common goal lies in *communication.*

- The leader must serve as intermediary in communicating to group members the principles and goals held by superiors and must also keep superiors current about group activities.
- The leader must see that there is good exchange of information between group members.

Groups must *develop techniques and skills* for problem-solving. After goals are defined and the roles of individual members are assigned, it remains to define means to be adopted by the group for attaining the targets and to identify the technique to be applied by each member.

- The leader must learn how the work is organized, and acquire relevant knowledge.
- . The leader must learn the skills necessary to do the work.
- The leader must master practical techniques for problem-solving, i.e., the seven standard tools for quality control as introduced in Parts 2.3.2 through 2.3.10.

Coordination with the administrative system and with other groups is required. To solve problems in the workplace, certain matters must be discussed and arranged with those higher up in the hierarchy or with associated staff personnel. Problems are sure to arise on such aspects as inspection and intertfacing with other groups in the same or other shops. Such coordination is another of the leader's important functions.

2.2.4 *Setting Targets*

Setting targets is the starting point for group activities. The appropriateness of goals chosen will determine the vitality of group activities. Non-intervention in group activities is assured, but the group is not there to play games. Goals must be selected that should lead to improvements in work being done on the shop floor. Goals should be practical.

At the same time, a group should be allowed to choose goals that permit both the group and its members to improve. For doing this, managers and foremen should help by suggesting goals that conform with higher level targets.

Basically, the targets for group activities should be selected from familiar day-to-day shop-floor level problems in which all members have interest.

Problems are either explicit or implicit. Explicit problems should be tackled first. They are the easiest to recognize by everyone in the group. As such problems are solved, the group should seek and pinpoint implicit problems. Finding hidden problems contributes decisively to the vitality of group activities. Addressing implicit problems requires:

Looking into every comer of the shop floor for wasteful, rash, or inconsistent practices.

Getting together to seek better ways of doing day-to-day routine work.

Scrutinizing problem areas and finding solutions that would permit achievement of the objectives set by superiors.

Dividing difficult problems. Certain problems may appear too difficult for the group alone to solve. If the nut looks too hard to crack at one bite, it can be attacked bit by bit. Each problem can be divided into smaller problems which should be resolved one by one.

Certain considerations for setting a quantitative target are:

- A target should be set high in order to challenge a group's problem-solving ingenuity, improve work performance, and contribute to enhancing the capabilities of group members.
- A target set high yields more satisfaction to the members upon its attainment. Sometimes this instills confidence with which to attack higher targets.
- A target must be within reach of the best efforts of members and should tax their ingenuity to the limit.
- A target must be set taking into account that a group's capability constantly improves as it gains experience in problem solving.
- If a goal considered by the group is worth trying at all costs but appears to be too high to reach in one step, it should be broken down into several steps and challenged step by step.
- Discussing a proposed target with all group members.
- Assessing a group's present capability from past data, i.e., both capabilities in problem solving and capabilities to perform work. When past data are not available, data should be collected over one or more months of trial.
- If trial data collection is not practicable, a figure should be adopted representing present group capability or a value from a comparable group in the same line of work should be used.
- A target should be based on an estimate of how much a group could do with its best efforts with a little extra added as a challenge.

Evaluation of the results achieved is made by combining:

- time (number of days, weeks, months taken for the activities), and
- achievement (total average, percentage of target value cumulative achievement, achievement by category of product).

Criteria should be chosen that provides:

- a true representation of the capabilities displayed with reliable records of performance data,
- no ambiguity in the calculations adopted in deriving the achievement values,
- intervals between measurements that are not excessive, and
- a reflection of the degree of effort exerted by the group.

2.2.5 *Implementation Plans*

The implementation plan should be as specific as possible and cover such items as:

- assignment of roles to members,
- time schedule for implementation,
- methods and techniques to be used,
- points on which to focus efforts,
- check-list of items required to be verified, and
- mode of holding meetings.

Once the implementation plan is in final form, a program containing requisite information must be drawn up and, after details are discussed with the group's superiors, submitted to the proper shop/section. A schedule for implementing a plan is shown in *Figure 2-1.*

2.2.6 Deriving Achievement Records; Reporting Results

In principle, achievement records of a group's activities are derived by the group leader. Their assessment is largely determined by evaluation criteria. What is important is to keep group members informed of how the group stands regarding performance. Thus, data and performance records are entered in check sheets kept individually for different items so that each member can assume responsibility and participate in checking data.

A group leader should inform members of interim and final results achieved by the group's activities, and submit written reports to superiors containing the substance of discussions and decisions made during group meetings.

Activity time schedule (Dotted lines: Projected. Solid lines: Actual record)

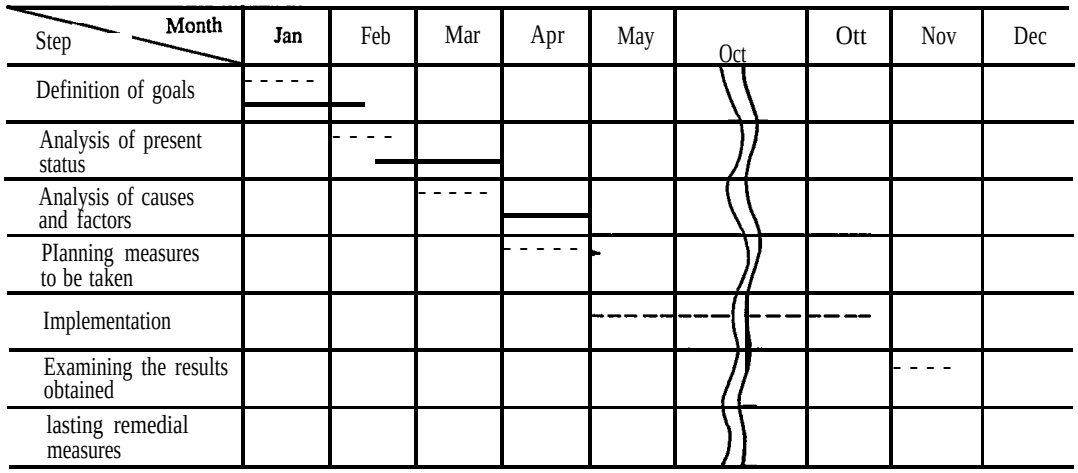


FIGURE 2-1: A Schedule for Implementing a Group's Plan.

2.2.7 *SelfAssessment of Group Activities*

Once a group's target has been achieved, the group applies for an award. But before applying, group members retrace their steps to reflect on how group activities went off. This is a critical self assessment of the results obtained. This review procedure lends impetus to the group's next efforts. A group's activities must continue, and by no means come to an end upon achieving one particular target. The next target, and the target after, must be successfully attacked, and to do so, it is essential for the group members to reflect on how far they were able to come, and on how they might have done better.

The items to be reviewed in a self-assessment procedure include:

- How targets were chosen
  - Were they chosen with a clear idea of how they stood in relation to the company policy upheld in the workplace, and/or how they pinpointed problems of the workplace?
  - Were they chosen based on a thorough survey (data collection), and on a good grasp by all group members of prevailing problems?
  - Were target-related suggestions actively put forth by members?
  - Was ample use made of the techniques and methods available for attaining targets?
  - Were there appropriate consultations and cooperation with groups situated upstream and downstream in the process flow?
- Results

  Does it seem that knowledge, skills and technical level were enhanced as a result of the group's activities?

  Has group teamwork improved?

  Were there improvements in efficiency, quality, and safety?

  Have regulations and standards been established as necessary to give lasting effects on measures devised and applied in the course of group activities?

GOAL ACHIEVEMENT SCORE SHEET

T O Y

	EXCELLENCE	GOOD	EFFORT

CRITERIA	DESCRIPTIONS	POINTS
1. How the target was chosen (appropri-ateness) 20 points	(1) Was there a clear correlation between the target adopted and the directives from superiors? (2) Was it chosen by the group on its own judgement? (3) Did it positively benefit the group? (4) Did the group have a clean grip of the situation before group action? Was the plan drafted appropriate for achieving the goal?	20 5
2. How the action was implemented (difficulties encountered) 40 points	(1) Were the steps "Plan-Do-Check-Act" taken in correct manner? (2) Was action implemented in united effort by the group and in the right direction? (3) Was the action implemented according to plan? (4) Were the group's ideas creative? (5) Were meetings actively and frequently held (other than regular meeting days, for example)? (6) Was appropriate action taken to enlist outside help whenever this was called for? (7) Were QC techniques appropriately applied for the action? (8) Were suitable steps taken to solve problems that arose in the course of implementation?	40 20 5
3. How much of the target was achieved (achieved degree) 20 points	(1) Was the target attained to 100%? (2) D1d the group feel a high sense of achievement? (3) Were the results assessed in monetary terms? (4) Has the result contributed to promoting the directives of superiors?	20 5
4. Lasting measures adopted (regularization) 20 points	(1) Were regulations and standards, as necessary, to give lasting effect to the measures devised and applied in the course of group action? (2) Have the results of the lasting measures been evaluated? (prevention of recurrence) (3) Was an effort made to establish similar standards and regulation in work where a similar situation prevailed? (4) Were improvements fully explained to the group members?	20 5

Note: To qualify for "Excellence" and "Good;' positive points must be scored for the items number (1) on all the criteria 1 *to* 4.

FIGURE 2-2: Goal Achievement Score Sheet Used in IHI's Aioi Shipyard.

2.3 *Scientific Approaches*

2.3.1 The Deming Control Circle

Usually when we do something, we begin by planning to achieve our goals. Then, following this plan we execute what we intended to do, and later check the results. If the results do not accord with the plan we take necessmy action. We modify the way we execute the plan or, if the plan lacked something, we modify the plan. This process can be viewed as a cycle, shown diagrammatically in *Figure* 2-3.

There are four steps in the cycle, i.e., planning, doing, checking and action — which is called the Deming control circle. It is very important in quality control group activities to follow these four steps in the sequence given.

2.3.2 The *Seven Standard Tools for Quality Control'*

Quality control is based on three representative elements:

- relying on objective data,
- effectively and extensively using statistical techniques to correctly gather and judge data, and
- emphasis on diagnosis rather than on therapy.

The elementary statistical methods known as the seven *standard tools for quality control* are used by everyone from top management to field workers, and it is said that 95 percent of the problems arising in an enterprise can be solved by using them.

2.3.3 *Pareto Diagrams (Tool 1)*

The Pareto diagram is a technique invented by Wilfredo Pareto, an Italian economist, to pinpoint the relative importance of different aspects of a problem.

It may be quite easy for us to list the kinds of defects that are currently encountered, but are we able to say offhand what specific kinds of defects occur in what percentage and/or in what order of importance? Pareto diagrams answer these questions.

In the case of pipe leaks, illustrated in *Figure 2-4*, resolution of the two most frequent defects, "loose bolting" and "packing left out," would prevent 70% of all leaks.

Per the Pareto principle, among an infinite number of conceivable causes of defects, only a very limited number will actually exert a major influence. Nearly always two or three causes together account for 70-90% of all defects or problems. Obviously, factors that exert a major influence should be targeted. A group must work first on the tallest bar in a Pareto diagram.

The PDCA Control Cycle

FIGURE 2-3: The PDCA Control Cycle

Pareto diagram
((Example of pipe leakage)

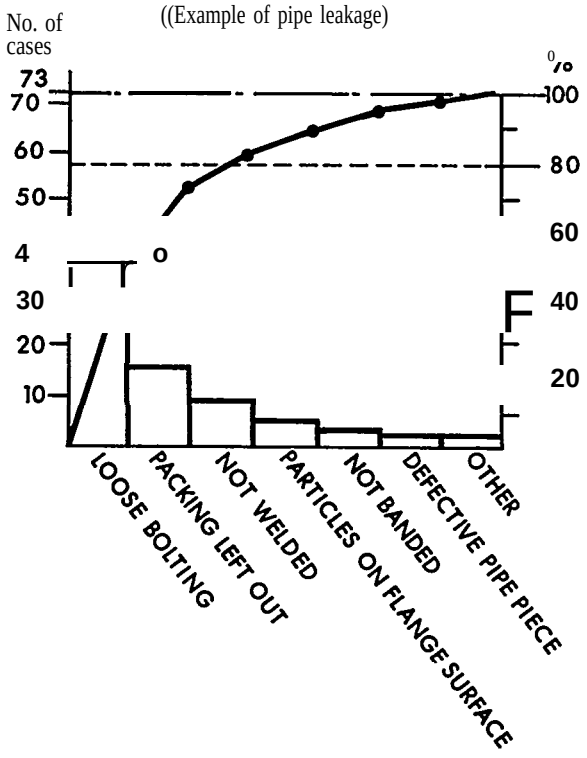


FIGURE 2-4: Pareto diagram applied to illustrate the relative importance of different leak causes in piping.

For a more comprehensive discussion of the seven standard tools for quality control, in English, see "Guide to Quality Control" by Dr. Kaoru Ishikawa, Asian Productivity Organization, Aoyama Dai-ichi Mansions, 4-14 Akasaka 8-chome, Minato-ku, Tokyo 107, Japan, Second Revised Edition 1982 (ISBN-92-833-1036-5).

2.3.4 *Characteristic-Factor Diagrams (Tool 2)*

Scoring a group's work depends on a combination of many independent factors and conditions, any one of which could detract from the overall value of the work. It is, therefore, important to analyze work systematically to find out which of the conditions were behind the result obtained, how they affected the score, and which provided the most telling effect on results (product characteristics) obtained.

How these factors affect work evaluation is shown schematically by Characteristic-Factor Diagrams (also called Fishbone or Ishikawa Diagrams), see *Figure 2-5.* The resulting product characteristic is what is indicated on the tight-hand side (corresponding to the head of the fish), while the "fishbones" represent the various factors that influence results. These factors can be divided into four basic categories:

- Materials
- . Machines
- People
- Methods

Stratification means dividing data into groups according to common characteristics, Divisions can be made according to potential causes or sources of defects, such as, by material, by type of product, by period of occurrence, by work team, by individual operator, by machine, and by lot. Such stratification facilitates pinpointing the cause of a defect or other problem and devising remedial measures.

Data stratification is indispensable for proper utilization of Pareto diagrams, histograms, and control diagrams.

Figure 2-6 gives an example of histograms representing the finished dimensions of a product. Stratifying by machines into three separate histograms, representing machines A, B, and C, clearly reveals that the defects are all found in components produced by Machine C.

2.3.6 *Check Sheets (Tool 4)*

An effort must be made to devise a method of recording that makes it easy both to record and to retrieve data. One way is to prepare a check sheet in which simply filling in appropriate spaces is all that is required. Check sheets for a record of workmanship and for key inspection items to be checked off in the course of work are shown in *Figure 2-7.*

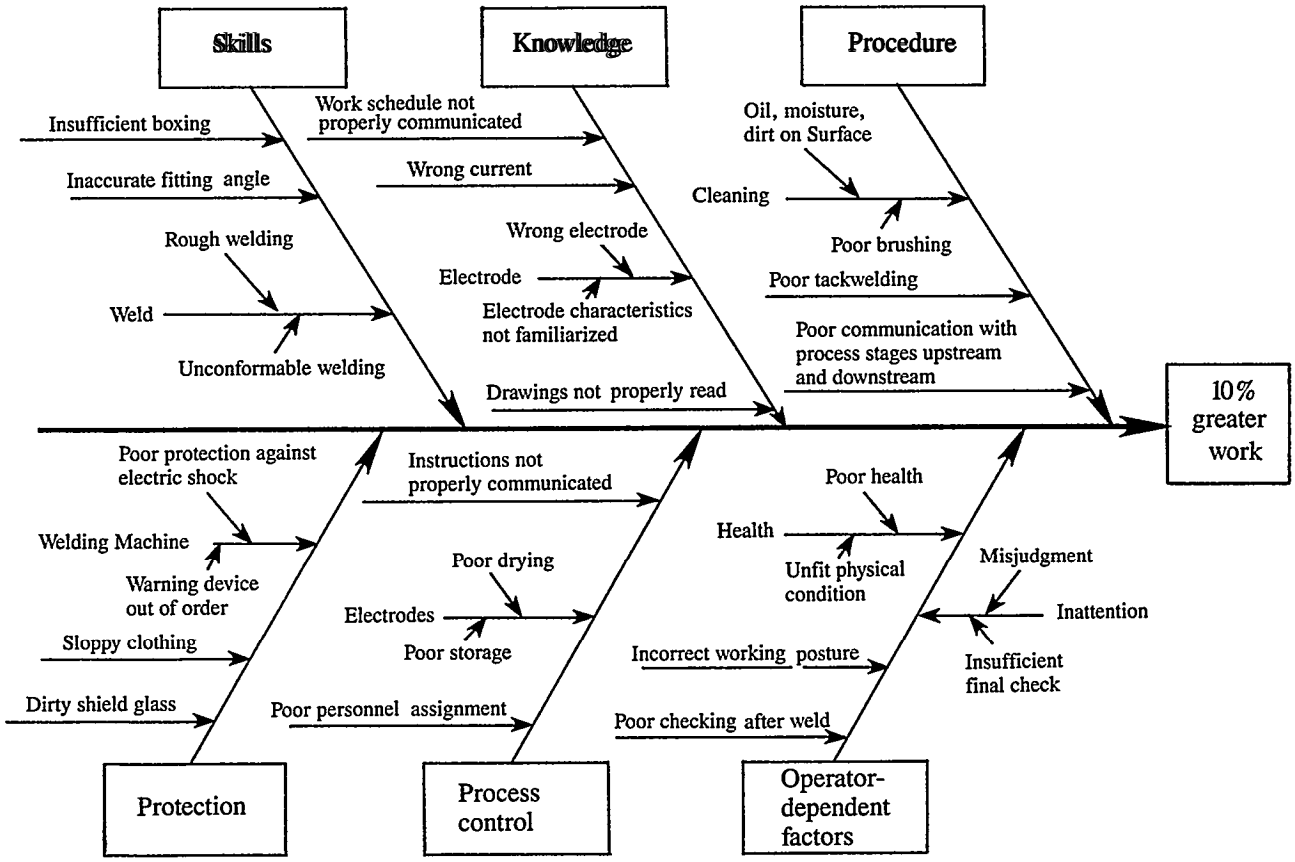
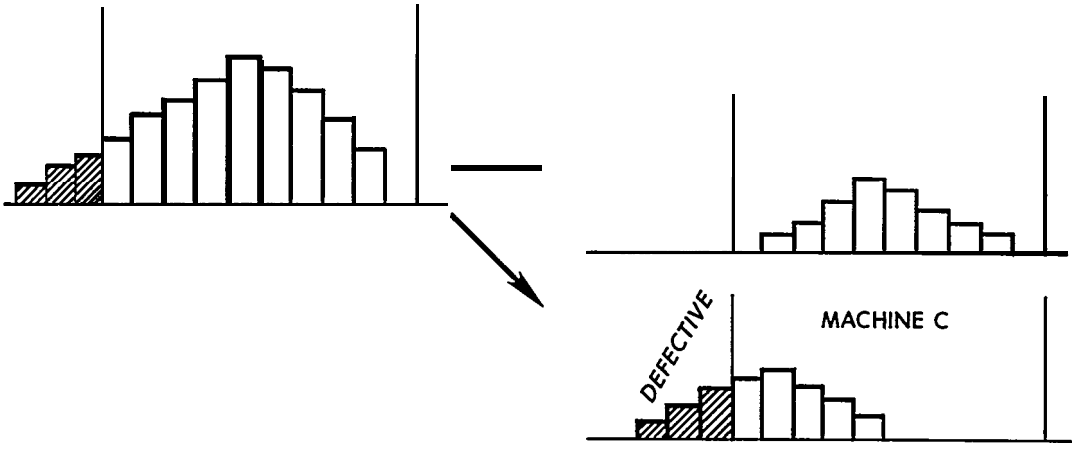
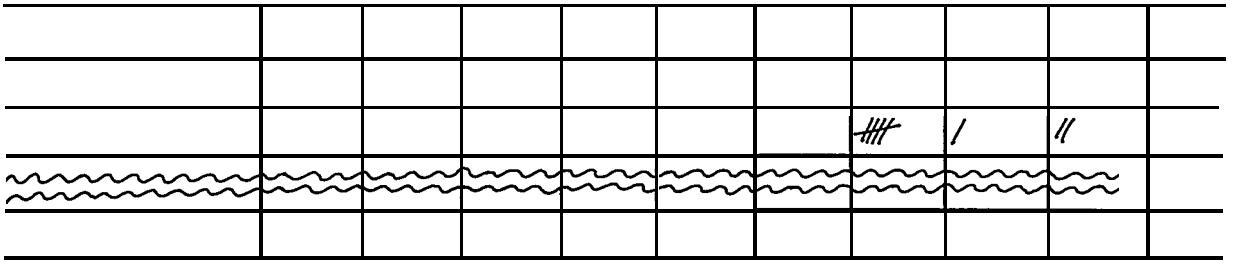
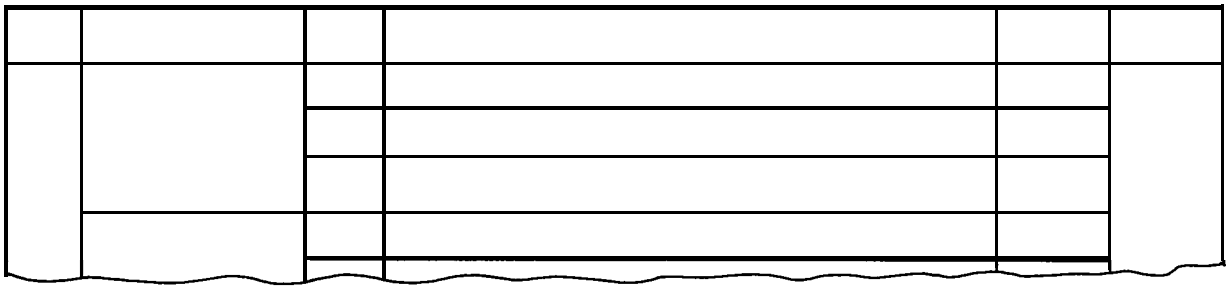


FIGURE 2-5: Characteristic-Factor Diagram showing problems which lead to inefficiency.


DEFECTIVE
MACHINE C





2.3.7 *Histograms (Tool 5)*

Histograms, also called bar graphs, show the degrees of deviation of measured data. Often judgments are made of quality or workmanship based on averages of values obtained from the results. But simply comparing average values can be misleadhg. Account must also be taken of deviations from average.

A frequency table is used to quantify the deviations. A histogram is a frequency table redrawn in graphic form to make it easier to read; see *Figure 2-8.* Thus the purpose of a histogram is to:

. make the extent of data deviation visible at a glance,

. compare the average value and extent of deviation between two or more groups of stratified data, and

make comparisons with reference values.

2.3.8 *Scatter Diagrams (Tool 6)*

Part 2.3.4. describes how to isolate factors likely to affect workmanship and to represent the resulting qualitative analysis on a characteristic-factor diagram.

A scatter diagram, another statistical technique, helps to determine the quantitative relation between the factors and characteristics, and find out whether or not a change brought to a factor will exert any influence on the product characteristics, and if it does, to what extent.

Pareto diagrams and histograms are techniques for analyzing one series of data. Scatter diagrams permit examining the quantitative relationships existing between the factors and the resulting characteristics, between characteristics and other characteristics, and between factors and other factors, to help in finding solutions to problems and in devising improvements.

Take, for instance, the relationship between the height and the weight of people. Viewed at random, there are heavy people and there are light people, but correlated with height heavier people are on the whole taller than the lighter ones. In other words, there is a correlation between height and weight. That is why the scatter diagram is sometimes also called a correlation diagrarn. See *Figure 2-9.*

2.3.9 *Process Control Charts (Tool* 7

A process control chart is a tool for checking whether or not a manufacturing process is characterized by only random variation of a stable process. It is a means of detecting any fault which could cause a process to go out of control.

Control diagrams resemble graphs, but differ in that horizontal lines representing control thresholds are drawn in above and below the-median fine. These thresholds, and the median line are derived by calculation from data obtained in actual operation. Daily data are plotted on a control diagram. A plot falling outside the threshold lines indicates a probable abnorreality.

Frequency distribution table

CLASS	BOUNDARIES BETWEEN CLASSES	CLASS MARK	TALLIES	FREQUENCY OF OCCURRENCE	%	CUMULATIVE %
1	259.5-272.5	271	/	1	1.25	1.25
2	272.5-275.5	274	///	3	3.75	5.00
3	275.5-278.5	277	//// /	4	5.00	12.50
4	278.5-281.5	280	//// //// //	16	20.00	27.50
5	281.5-284.5	283	//// //// //// //// /	21	26.25	53.75
6	284.5-287.5	286	//// //// //// //// ////	19	23.75	77.50
7	287.5-290.5	289	//// //// //	12	15.00	92.50
8	290.5-293.5	292	///	3	3.75	96.25
9	293.5-296.5	295	//	2	2.50	98.75
10	296.5-299.5	298	/	1	1.25	100.00
	Tots 1 or Average			[illegible]	[illegible]	

Histogram

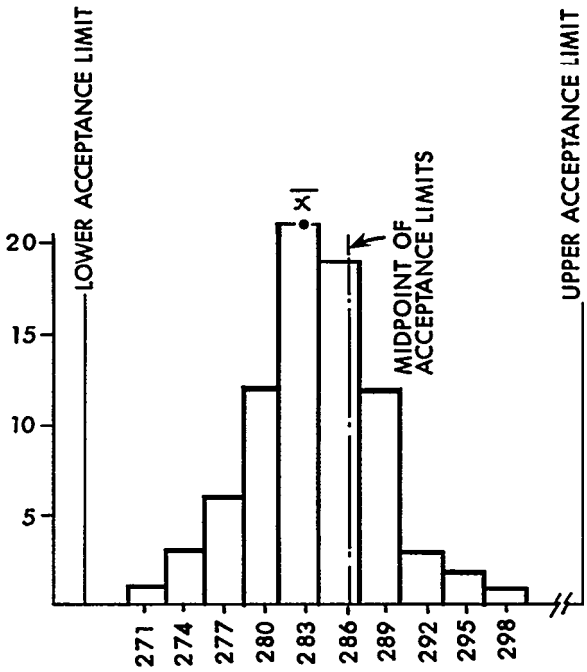


FIGURE 2-8: Relationship of a frequency distribution table to a histogram.

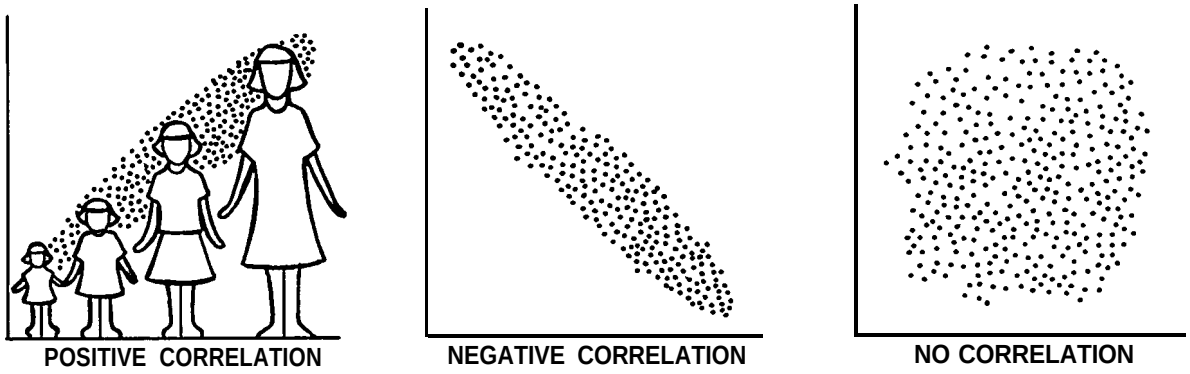


FIGURE 2-9: Correlation in scatter diagrams. When drawing a scatter diagram appropriate stratification of the data is essential, or else the result can be found meaningless.

In the past, judgments of this sort were made on the basis of experience or intuition. Use of control charts provide a firm basis with which to make better judgments based on analytically derived knowledge. See *Figure 2-10.*

2.3.10 Review of the Seven Standard Tools for Quality Control

At the stage of defining the problem, questions asked are:

- What is the problem? (Pareto diagram)

What has the situation been so far? (histogram, check sheet, scatter diagram, process control chart)

What is the relation between cause and effect? (characteristic factor diagram)

At the analysis stage, questions asked are:

- What does stratification show? (histogram, process control chart, scatter diagram)
- What are the correlations between factors? (scatter diagram, process control chart)
- What are variations with time? (process control chart, check sheet)

At the stage of determining the effectiveness of countermeasures, the question asked is:

- Have the countermeasures been effective? (process control chart, check sheet, Pareto diagram)

At the final stage of having established lasting remedial measures of standardization and control, the question asked is:

- Has the process stabilized? (process control chart, check sheet)

See *Figure 2-11.*

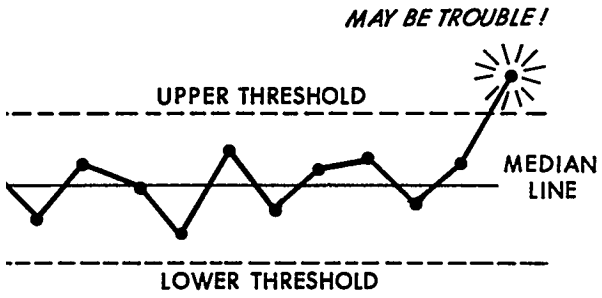


FIGURE 2-10: Control charts aid in making better decisions for improving quality and productivity.

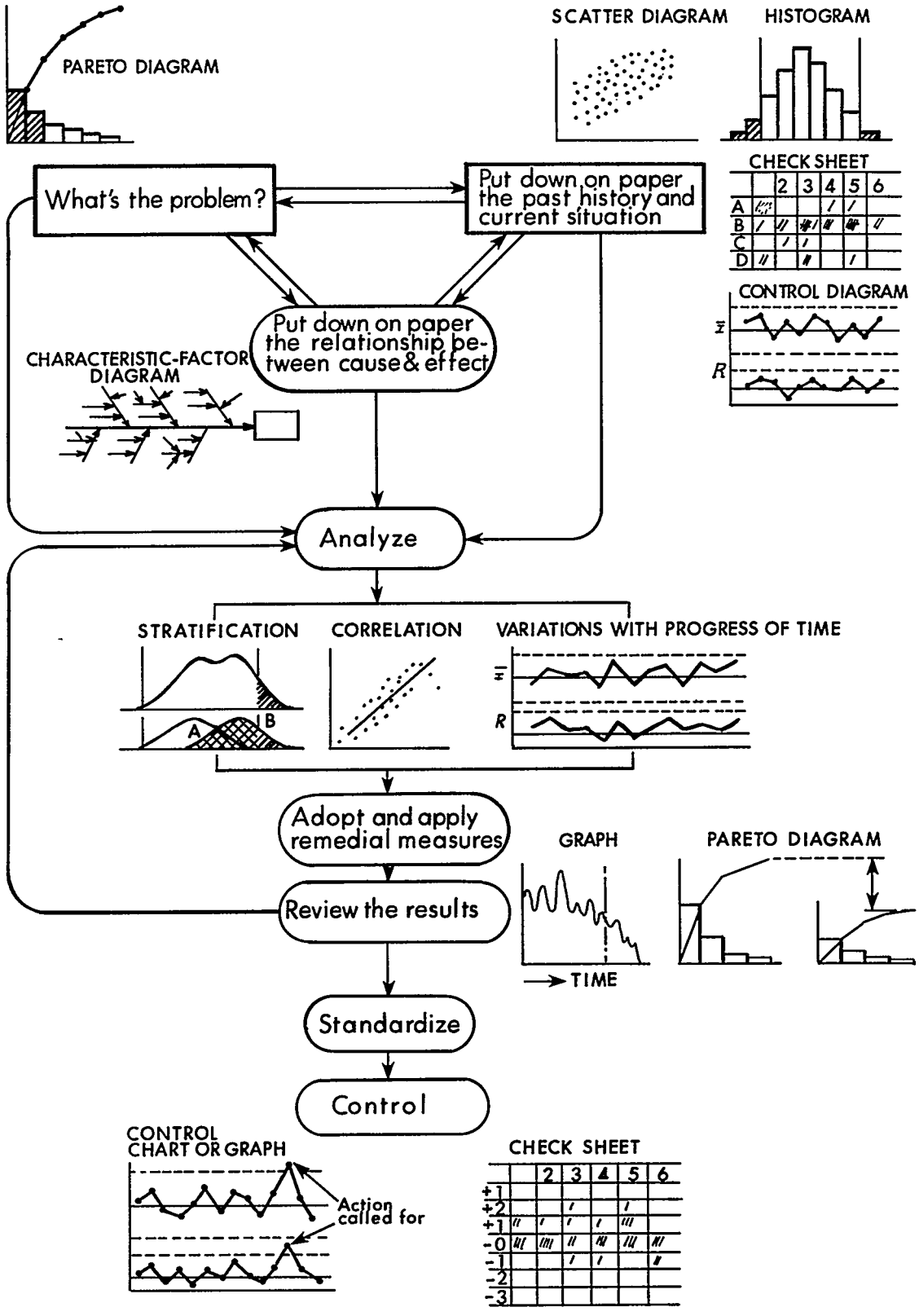


FIGURE 2-11: Use of the Seven Standard Tools for Quality Control.

4 *Group Meetings*

2.4.1 Why Have Group Meetings?

Holding meetings is a very important part of a total quality control movement. Meetings provide occasions for people to talk to each other about what they think of the TQC movement, progress made so far, and ideas for how they should proceed.

2.4.2 *Preparing for Meetings*

One hour meetings should be conducted twice per month where participants would not be disturbed. Approximately one half of each meeting should be devoted to safety and health matters with the remaining time devoted to quality and productivity. The timing of meetings should be chosen so as to let all members attend with minimal interference with their conduct of work. The meeting program should be planned with time scheduled for each discussion topic so that maximum coverage can be ensured in minimum time.

Working documents necessary for conducting discussions should be distributed beforehand in order to let participants familiarize themselves with the points at issue. Such materials might include:

. tables and graphs showing progress to date,

characteristic-factor, Pareto diagrams, etc., and

• minutes of previous meeting.

Depending on the discussion topic, there should be on hand blackboards, pin-up boards, memo sheets, chalk, felt markers, etc.

2.4.3 *Kinds of Meetings*

Meeting can be held for any of the following three basically different purposes:

• for reporting and for transmitting information,

. for discussing a problem, and

• for imparting instructions with an educational objective.

Of the different meeting patterns described below, the one best suited to the particular purpose should be adopted:

• The most *regular pattern* is characterized by:

- a small number of participants seated face to face,

- speaking out at random, and

- an experienced moderator guiding the discussion.

• *Panel discussions* feature all participants discussing at random. Discussion is limited in the first period to panel members, who freely exchange in depth views of the subject being treated. The discussion is later opened to the floor for comments or questions. Panel discussions are characterized by:

a large number of participants with panel members first having a discussion among themselves, and afterwards

a general discussion in which other members participate.

• *Group discussions are* characterized by:

participants being divided beforehand into several groups, each group with its designated sub-leader,

a session beginning with all members participating in group discussion and led by a moderator, who ends the discussion when its benefits are exhausted,

the session is then broken up into the previously designated groups and discussions are separately continued, and

the session closes with a second full-group meeting, this time taking the form of a panel discussion in which only the group sub-leaders take part.

• *Brainstorming sessions are* used for unearthing the roots of a problem or for deriving original ideas For needed improvements. During a brainstorming session:

expression is free and unstructured,

participants may not criticize other people's opinions,

participants are encouraged to build on other people's ideas in formulating their own, and

the aim is to generate the maximum volume of ideas in minimum time.

2.4.4 *Posing Questions at Meetings*

Moderator's questions are important for conducting a meeting. Skill in posing them can make the difference between a successful and an unsuccessful meeting. There are ways of posing a question:

• General questions (Does anyone have a question?)

After an opening explanation on the topic or the problem being treated, the question is directed at the whole group.

This draws the attention of the group, incites the members to think, and creates an atmosphere where everyone feels free to speak out their views.

- Directed questions (A, what do you think?)

  After a general question, the question is directed to someone-who is versed in the question; this also serves to leave other people with some time to reflect.

  Then the moderator can call on other people by name. This could provide an occasion to urge those who are not speaking out to give their views.

- Relay questions (B, what is your reaction to A's statement?)

  - The moderator would summarize the first speaker's view and call on another participant for his reaction.

  - Such relay questions have the effect of stimulating the other participants.

- Indirect questions (What does the group think about what A and B said?)

  - A questions raised is thrown at the group as a whole.

  - The moderator, instead of answering a question directed to him, lets the group think of the answer as a general question.

2.5 *Improvement Suggestions*

2.5.1 *Suggestions*

Suggestions made by company employees have significance in that they bear three important results:

- Employee suggestions borne of their creative efforts and which contribute to the growth of the company and of the works or shipyard can yield benefits by:

  - eliminating accidents in work,

  - reducing expenditures in materials, labor, and overhead,

  - improving the working environment - equipment, facilities, etc.,

  - improving product quality,

    improving shop and office work procedures; saving time spent in work,

    improving tooling and jigs, and

  - economizing consumables, etc.

- Suggestions from subordinates enable superiors to know the problems confronting those who are under them and the way they think of things. Those down the line of command, on their part, get the chance of increasing their contacts with their superiors and of knowing them better. In this way, communication improves within, and also between, groups which contribute significantly to improving personnel relations.

- Employee suggestions contribute to enhancing morale. Presenting suggestions is participating in management. A suggestion accepted will generate satisfaction in one who has actually contributed to bettering the company. This will further strengthen sense of participation.

2.5.2 *Getting a Suggestion Accepted*

Factors which lead to acceptable suggestions are:

- Problems, ideas, and improvements are things that will come to mind if one makes a point of keeping constantly alert for them.

- When something wrong is noted, or a bright idea comes to mind, jot it down right away.

- Put down specific facts; leave out emotion.

- Before proceeding, carefully consider whether or not the group could solve the problem.

- Wherever possible, formulate the suggestion in itemized form: Who, what, where, when, why, how?

- Try to put the point across clearly and concisely; no need for fancy phrases and flourishes.

- Remember, suggestions from individuals can usually be improved through group discussion.

- Accompany the suggestion with sketches and graphs whenever possible and appropriate.

- Study quality control techniques and other methods for devising improvements.

- When the suggestion calls for urgent action, make good use of ways and means that permit quick solution of the problem.

- The superior receiving a suggestion must strictly refrain from assuming a negative attitude.

- What is most important is for everyone to get a clear notion of the true intentions behind the suggestion.

2.5.3 *Submitting a Suggestion*

The initiator of a suggestion enters the necessary items on the TQC Movement suggestion form (see Appendix A) and presents it to his group leader. The group leader submits the suggestion to the group for discussion and to gather further ideas for its improvement. Then it is sent up through appropriate company channels.

2.6 *TQC Awards*

2,6.1 Awards

The company hands out awards to groups that have achieved their targets and to authors of outstanding suggestions with the view of effectively promoting the company's TQC Movement.

2.6.2 *Group Awards*

To qualify for an award, a group normally must attain the envisaged target through the joint efforts of its members. Also the group must be considered able to maintain the target performance as a result of the suggestion.

In special cases, even when the target has not been quite met, if its effort or results are nonetheless outstanding, a superior may authorize the group leader to apply for an award.

Depending on achievement, awards are given in three ranks:

- Excellence
- Competence
- Effort.

When a group considers itself qualified for an award, it submits through established channels a formal application together with supporting documents as prescribed below:

- Application for award (including the implementation plan; see *Figure 2-l).*

. Self-assessment table of activities drawn up by the group (Goal Achievement Score Sheet; see *Figure 2-2).*

. Other relevant documents, e.g.:

- Account of how the target was set.
- Analysis of the previous situation and account of how the problem was pinpointed and countermeasures devised.
- Summary account of measured results, of standards established, lasting remedial measures adopted.
- Suggestions made in relation to the target envisaged.
- Data and graphs: Characteristic-factor diagrams, Pareto diagrams, etc.

The group's achievement is assessed on the basis of the criteria in the Goal Achievement Score Sheet.

2.6.3 *Awards for Outstanding Suggestions*

Outstanding suggestions for improvement that qualify in substance under the company rules, entitle the author(s) to apply for an award in accordance with the award rules. Individual awards are made every month. A yearly award is accorded on the basis of cumulative points. Awards are given in four ranks, from A to D. Ranking is determined in conformity with the rules of each shipyard or works.

3.0 APPLICATION OF TQC

3.1 *Prerequisites for Application*

3.1.1 *Requisites to Introduce TQC*

TQC which came to Japan from the U. S. A., takes the view that *a client's requirement cannot be totally met by simply applying TQC in the production line. It is essential to comprehend and digest the client's needs and establish a comprehensive and organized QC structure encompassing development, engineering, production, sales and after sales services.*

However, after its introduction to Japan, the above concept has been gradually transformed to a Japanese style of TQC which interprets *total* as a *company-wide movement,* and views QC as an activity which requires involvement of all company employees from top management to workers, and requires each worker to be sensitive of quality and have it routinely incorporated in work.

As time passed, the concept of quality control changed from the days when it simply sorted out good or defective quality products through inspection after the fact, to Statistical Quality Control (SQC) and, eventually, to TQC which expanded quality control from the production line to a company-wide total QC activity, i.e., control before the fact. Further, the object of *quality is* becoming not merely limited to the quality of products, but extended to the quality of operation and, eventually, into company management and administration. Thus, TQC is now becoming a tool for company management and control.

What does a business enterprise expect from TQC? Naturally, the aims and expectation will differ depending upon a company's policy and environment, but could be summarized as follows:

. To nurture the capability to diversify as necessary to meet changing social demands.

- To establish a structure that can concentrate all company resources, allow all company employees to participate in management (QC activities), and establish a spirit of mutual collaboration.
- To establish a quality assurance structure which gains the reliance of customers.
- To improve the company's make up to meet changes in social demands and/or circumstances and maintain profitability.

. To constitute a work environment which respects human rights, fosters talent, provides happiness to all employees, and brings vitality to work sites.

- To reform or reorganize everyone's TQC consciousness, etc.

Most compnies which were awarded the Deming Prize chose *improvement of the company's make up* as the first objective for breaking out of the stalemate of traditional methods. Second priority was given to management (QC activities) participation by all employees.

They brought in TQC as an activator. In other words, the underlying conception was that, in order to join all company resources together and to foster active and vital human groups, it is essential to have all employees take a common scientific approach. TQC is the best means to satisfy this purpose.

The likelihood of success is rather high when top management sets up clear objectives when introducing TQC and is much higher when the program is integrated with a long range management plan.

Before proceeding, it is prudent to evaluate the need for TQC, its impact, organization, expense, advantages, disadvantages, etc., by setting up an adhoc group. Once the evaluation is concluded as positive, top management should announce a clean-cut policy to implement TQC with all employees participating.

Other requisites include the establishment of an executive office to promote TQC activity, and an organization to plan and prepare for systematic implementation.

An easy way to bring in TQC is to start with statistical control techniques. Many people think incorrectly that Quality Control Circles (QCCS) have their origin in human development studies. Instead, QCCS emerged from the introduction of management innovations that are based on sound scientific principles. The first, *Group Technology,* has led to product-oriented organizations which, even for something as complex as building ships, feature small groups of workers organized to match stages in production lines.'

Experience with *Statistical Control, the* second innovation, disclosed that when worker teams are provided with knowledge indicating when their processes tend to behave abnormally, they spontaneously respond with suggestions to restore normalcy. The response capabilities, when supplemented with training in analysis techniques, such as the seven tools for quality control *(Parts* 2.3.2 *through* 2.3.10), become means for *constant* improvements in work processes. Subsequently formalized, such small groups came to be known as QCCS.

QCC activity requires clear identification of its objective and the best means to accomplish its objective. Accordingly, the activity should be aimed at "problem-solving" rather than "maintaining formality;' and the procedure to implement such activity is to break down the objectives and/or targets into manageable steps and to setup appraisal indices and execution plans for each step.

Before starting QCC activities, it is essential to provide education in and discipline for the methodology to solve problems, and to upgrade the capabilities of individuals.

3.1.2 *Procedures to Induce QCC Activity*

Although QCC activity is an autonomous function, each QCC is made up of people who are engaged in regular jobs, usually associated with a work station. Therefore, in promoting QCC activity, it is essential to establish a basic policy and procedures in order to achieve the best results. The following are some basic procedures for promoting QCCS:

- Above all, leadership by top management and an upsurge of willingness of all employees is essential. Therefore, the first step is to formally announce the implementation of QCC by top management, and start education of managers, supervisors, foremen and staffs, and to spread the mood, company-wide, through publications and other means from the executive office.
- The next step is to establish an organization to prepare promotion plans, guidance books for execution, etc.
- Hold kick-off meetings to explain basic policies from top management, and detail procedures from the executive office.
- Carry out educational programs for group leader candidates, such as new concepts of quality control, management methods, concept and technique of statistical methods, etc.
- Organize groups by work stages. Usually, a group consists of 5 to 6 persons led by an Assistant Foreman (AF), i.e., immediate supervisor.
- Select appropriate themes. At start-up, select themes which are easy to understand. First, take up problems which can be handled under the leader's responsibility and/or authority, and then, gradually take up problems that relate to the shop's (or section's) policy. Finally, when all members get used to this activity, take up larger problems which could be divided and taken up by multiple groups.
- Collect and analyze all data and information pertinent to the selected theme. Let the members get used to Pareto diagrams, characteristic-factor diagrams, etc.

By following the above procedure, group members will understand the objectives of QCC activity, how they can participate in achieving objectives, how they can relate their jobs with objectives, etc., through mutual discussions and debates.

3.1.3 *Pre-Education Required in Introducing TQC*

For managers and supervisors, the following education is considered necessary:

- Basic concept of management and statistical control.
- The basic concept of quality control and how to assess quality.
- How to sort problems, how to seek solutions, and how to apply solutions to improve work.
- Reflection on what is small group activity.

The methodology of problem-solving, as described in Chapter 2.0, can be categorized by its objectives as follows:

To "discover" problems:

Pareto Diagrams: Useful for identifying the various causes of defects, and to determine the priority items to improve.

Characteristic-Factor Diagrams: Useful for identifying all problem factors, and to find the primary factors which affect characteristics.

Histograms: Useful for investigating the distribution pattern of data and to compare the data with the normal distribution (usually, 30 to 100 data points are required).

Graphs: Useful for consolidating data, for comparison with other such consolidations, e.g., actual work progress against scheduled work, comparison of progress between work groups, etc.

1 "M0St Japanese. managers know that the establishment of Quality circles is not the first but the last step in buildlng a corporate system that Will Support a company's total commitment to product quality and productivity." Dr. Y. Tsurumi, The Dial, September, 1981.

. To collect facts and/or determine targets:

- Pareto Diagrams: For determining priority items that cause the most defects.

- Graphs: For tracking performance relative to targets for improvement based on specific feature of the problem.

• To analyze the cause of deficiency and investigate its solution:

- Control Charts: For identifying defects or irregularities, points outside limit lines, tendencies, cyclical periods, etc.

- Histograms: For investigating the statistical distribution and/or the difference between the actual results and normal by types of machine, workers, raw materials, work processes or methods, etc.

- Scatter Diagrams: For analyzing the relationship between the causes and results by collecting and comparing the data of the above two factors (20 to 50 data points are required).

- Check Sheets: For checking causes of problems or deficiencies, and to transform them into graphs or charts.

- Graphs: For consolidating data. It is convenient to use line graphs to see variation based on time, bar graphs (or charts) to compare two or more data elements at one time, and circle graphs to see percentage distribution.

The above are the most understandable and explicit visual methods used in QC, categorized by objectives. Good advice for achieving effective QC is to make full use of simple methods. Almost 95% of the problems that occur at a job site can be solved by skillfully utilizing simple methods.

What is desired for a group leader is a person who has abundant experience, knowledge and wisdom of assigned work, and competency in leadership. The following are the personality traits for a leader:

. A person who can represent the group

. A person who can act as a lead-off man

. A person who takes final responsibility

• A person who can coordinate and unify the group

• A person who can guide and educate his fellow members

Naturally, it is easier to operate a group which was organized to match a work stage, and when the assistant foreman is assigned as its leader. The success of group activity is normally dependent upon how well the group leader manifests leadership.

Leadership is a human factor which has great influence and persuasion on people of different opinions, regardless of age or position. Therefore, a leader must have the capability to persuade and unify a group and, moreover, must display aggressiveness and humanity.

There are two important factors which confirm leadership:

. the degree of satisfaction a member feels toward the group, and

• the degree of achievement relative to a target.

The former keeps the group together and causes it to operate smoothly (people control). The latter motivates a group to achieve a target (job control). Leadership combines these two factors. Results are related to how the two factors are combined.

As shipbuilding has become more scientific, worker philosophy has changed. Effective organization of work through *Group Technology* concepts and information of how work processes perform, such as made available by statistical control tectilques, have made workers very aware that they too can make meaningful contributions in what had been only management's area. Workers now expect to participate. In IHI shipyards, the era which was characterized by command has been replaced by an era of encouraging meaningful worker participation, a more difficult leadership challenge.

Because the concept of leadership will vary depending upon the character and talent of a person, the boundary circumstances, the characters of group members, etc., it is important to let leaders determine what is needed for leadership, and for each leader to apply self discipline to meet those needs.

Leadership can be fostered in many ways. The following are some means:

- A leader must have vision and opinion of what group activity should be, and must convey them to group members. Members will not follow if a leader lacks opinion.

- A leader must take initiative as an example to others.

- A leader must deal with matters wholeheartedlv. If the members recognize that their leader is exerting best efforts and sincerity in doing something, they will have respect and follow accordingly.

Educating leader candidates in the objectives and the meaning of QCC activity is essential. The following education is needed:

• Methods of analysis.

• Human relations.

Workers are the core of QCC activity. Therefore, the key to success is to raise the workers' awareness of quality control. Before educating workers in QCC methods, they should:

- recognize the part of the end product being made,
- understand the entire flow of the work process,
- be told what quality is required,
- understand where and how their interim product is to be used and its significance,
- understand the need for a quality target, and the need to reduce dispersion of product quality, and
- be able to identify good and defective quality.

Workers can be educated in QCC activity in two ways. One is to let group leaders educate group members. The other is to encourage group members to read selected themes. The former also educates the leader who must study and comprehend before attempting to instruct group members.

Educating workers at their job sites, using actual data obtained from the jobs and actually applying the various QC methods is a very effective teaching approach.

The education course should include the following:

- concept of QCC activity,
- concept of quality,
- how to make improvements,
- statistical methods, and
- the seven standard tools (Pareto diagrams, characteristic-factor diagrams, stratification and 'check sheets, histograms, scatter diagrams and control charts).

Special TQC training for managers, shop/section staff engineers and foremen which started in 1983 in the Shipbuilding & Offshore Division of IHI, consists of a 2-day special course to teach the philosophy of TQC. The course is conducted by instructors from IHI's Production Technology Research Institute supplemented by shop/section staff engineers who had received special training.

The following curriculum is used:

- First day:
  - Aim of TQC course.
  - What is TQC? What is the objective of applying TQC?
  - Quality Assurance.
  - Management activity, ways and means of improvement.
  - Small Group activity, and the role of management.
  - Respect of human nature.
  - TQC for managers.
  - Recap of TQC ideology.
  - TQC methods and techniques.
  - Standard tools for QC.
  - Exercises in use of standard tools for QC.
- Second day:
  - Concept of SQC.
  - Exercises in TQC methods and techniques, and presentations by student teams, questions and answers.
  - Review and comments.

In addition, actual case histories of QCC problem solving, called QC stories, are presented for discussion.

3.1.4 *Features of Japanese Style QCC Activity*

The perception that Japanese style QCC activity can only exist in the special social circumstance of Japanese society is incorrect. Management science, not culture, is responsible for the success of QCCS in Japan. Managerial initiatives include:

- Relating quality control activity to the whole company operation.
- Thorough education and training in QC matters.
- QCC activity fostered patiently by allowing ample time.
- Top management devotes time to periodic and public reviews of QC stories and for meeting with group leaders.
- Statistical analysis methods are extended to the worker level.
- Quality control activity is promoted on a company-wide scale.

In contrast, the QC concept typical of traditional firms outside Japan has the following features:

- QC is carried out by QC specialists.
- There are national organizations which emphasize the status of QC specialists rather than directing effort at improving quality.
- Statistical analysis methods are not exploited by workers.
- QC education is rarely applied to personnel other than QC specialists.
- Worker capabilities to solve problems are underestimated.

The reasons why the ZD movement, which bloomed and died elsewhere, was successfully linked to QCC activity in Japan are:

- The ZD movement did not consist of just slogans and exhortations. It was supplemented with analytical methods.
- Various QC methods were associated with ZD activity and group leaders and members were educated to skillfully employ them,
- People were educated to review existing rules, standards, etc., based on a philosophy that nothing is absolutely perfect.
- Even though numerical results were considered important, respect for human nature was considered more significant because people control the figures.
- Personal initiative was emphasized.
- People upstream from production, such as engineers, participated-in solving problems and remedying defects.

Regarding TQC, although there are some differences in U.S. and Japanese cultural and social circumstances, some first-class U.S. firms have applied an approach which, in concept and effect, is similar to Japanese-style QCC activity, and have succeeded in expanding it into TQC activity. There is no reason to believe that the same process cannot be repeated in U.S. shipyards.

3.2 *Historical Progress of TQC in IHI*

3.2.1 The *Progress of Small Group Activity in IHI*

Because of experiences with many shipbuilding contracts during the sixties, the Japanese shipbuilding industry was able to conceive procedures which insure good relationships with owners supported by mutual trust. With a very simple contract, each owner would be assured of getting the quality desired and per classification society requirements. But, since the 1970's, *product liability* became a serious consideration.

When an accident occurred in a ship during its operation, the builder responsible for design, production and after-service became the target of liability. More and more product liability issues are not limited to safety, but are being extended to other areas such as pollution. Once this kind of litigation occurs, the impact on the company's operation is very serious. Its very existence could be jeopardized.

Satisfying established classification society rules can no longer be an excuse to evade product liability. Sophisticated products such as LNG carriers, offshore rigs, etc., require especially stringent quality standards to meet owner's requirements and it is a shipyard's responsibility to explore how the quality required by customers' proposed usage can be built into products. Therefore, the shipyard by its own will and effort, has to renovate its physical structure to cope with this new demand. Shipyards have to upgrade their quality criteria and their traditional processes of quality control. They must now address the following:

- Is quality directed to customers' needs?
- Is there too much emphasis on productivity at one stage which is causing production problems downstream?
- Are jobs really structured to meet the new demands?
- Is the plan-do-check-action (PDCA) cycle properly applied in the management of routine jobs?
- Are countermeasures applied just as a stop-gap measure? Have measures to prevent recurrence been established?
- Is each target set a step ahead as a challenge?

Answers to the above and other such questions, demonstrated need for a more scientific approach, conceptually shown in *Figure 3-1,* to meet the challenges of product liability acerbated by intense competition.

Old concepts were reviewed, modified, supplemented and, since about 1979, issued as a TQC movement:

- The way of forming groups was reviewed. Thereafter, QCCS became the actual groups organized to match specific stages in work flows. In other words, groups became specialized along product lines.
- Setting targets was reviewed. Targets then began to apply to routine work, with safety, working smarter not harder, efficiency, etc., as objectives.
- The conduct of group meetings and reporting was reviewed. Clerical work was reduced.
- Suggestions for improvement were reviewed. More importance was placed on *group* proposals rather than *personal* proposals.
- Rules for appraisal of proposals were reviewed. Priority was placed on group awards so as to emphasize group activity.

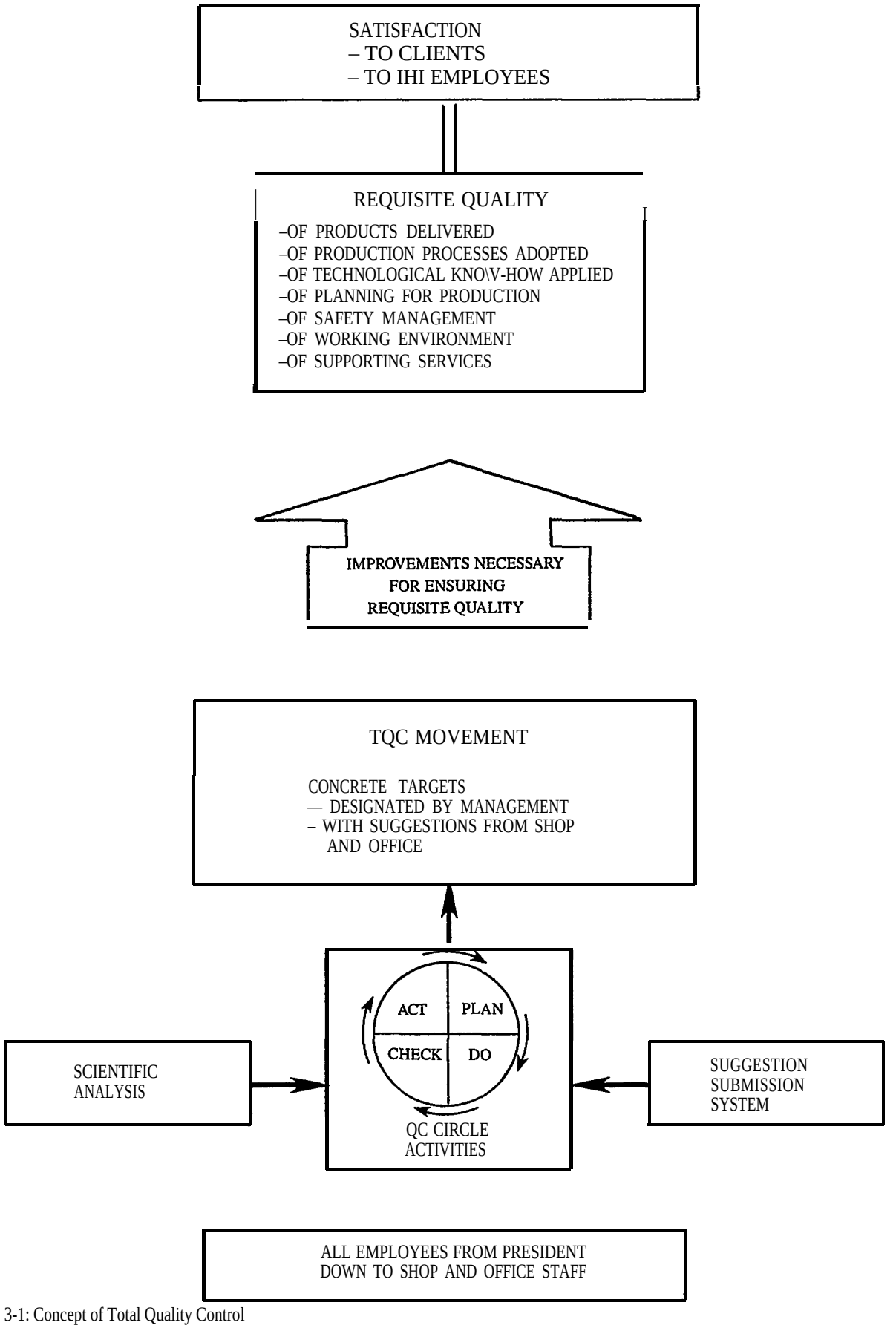


FIGURE 3-1: Concept of Total Quality Control

More specifically, the direction of the shift to TQC included the following actions:

- More priority was placed on *how the group solved problems* rather than on results as a way of fostering groups. Whth increased capability a group could obtain higher scores (e.g., become eligible for *superior* or *excellent* grades). In each fabrication shop and assembly section, a production engineer or foreman was assigned collaterally to educate and guide groups for the purpose of strengthening their capabilities.

- Attaching too much importance to *group* proposals could cause an-individual who took the lead in a proposal to be overlooked, with adverse impact on morale. Therefore, some effort was applied to acknowledge individual contributions.

3.2.2 The *Era of the Company-Wide Movement*

The primary objective of TQC in IHI's Shipbuilding Division was to establish a true Quality Assurance (QA) and Quality Control (QC) system. In a narrow sense, it means product quality and, in a broad sense, it means to improve the quality of the entire Division so as to achieve full confidence of clients.'

In the past, group targets were designed to realize shop targets. As a result, most of the group targets addressed cost reductions. This movement caused people to spend most of their group time only in comparing budgeted and consumed manhours and to neglect improvements in tools, ways to do a job, and quality.

To remedy this situation, targets were shifted to address improvements in accuracy so that cost reductions would be achieved indirectly. To promote and accelerate this movement, changes in targets were discussed with the small groups. From these discussions it was recognized that in order to impose top management's policy in the "front" line, more middle management involvement would be required. Simultaneously, it was realized that more scientific control must replace traditional concepts for controlling quality.

What *scientific* means is to capture numerical figures, analyze data, process arithmetically, find tendencies by using graphs, and based on the so processed facts, grasp the crux of the problem, find remedies, and execute solutions. This approach was considered necessary to revitalize the entire company.

Small Group activity adds a second dimension to the organization. Besides the traditional top-down instructions from management, QCCS create bottom-up communications from the workers. Accordingly, improvements in the production field are devised voluntarily by the workers on work sites who have the most immediate knowledge of work situations. Management and supervisors are expected to be involved in this activity as advisors and/or instructors.

The next TQC objective was to nurture the consciousness of running the company with the participation of all employees. This required every worker of every department to participate collectively, i.e., to make use of their combined knowledge and expertise. More specifically, it required department managers to set up policies in accordance with higher management's policies for achievement targets and to determine definite means for reaching the targets. This necessitates that every worker adopt scientific methods and think scientifically. To achieve the set targets, workers thoroughly examine their shop, identify problem areas, and set up their own improvement targets.

3.2.3 *TQC Objectives by IHI*

In general, II-II's TQC objectives are:

. participation by all employees,

- assurance of product quality,

- improvement of job quality, and

- organized activity.

Based upon the above, TQC is a process for producing a product for which quality, cost and delivery terms meet the user's satisfaction. At the same. time, it includes all activities to upgrade and stabilize job qurdity level, and to keep jobs under control. In other words, TQC is a comprehensive activity for improvement in which all employees participate. Its objective is to upgrade the entire level of management and control with quality assurance as the core. To do so, it is essential to utilize scientific methods, enhance current technologies, and promote small group activities.

In the Shipbuilding Division, emphasis was placed on the following points:

- making everyone understand management and control techniques utilizing scientific ideas and methods,

- fixing a consciousness in the organization that the next process is the important "client," and

- pursuing QC to the fullest extent by circulating the PDCA cycle.

QA is the objective and QC is means for achieving QA.

Traditional control techniques are usually affected by a company's history, social environment (community), etc., which are hard for management to influence. Therefore, a scientific control technique must be mastered. The following questions help to keep scientific methods in focus:

- Is the PDCA control cycle being properly applied? Are we just doing planning and forgetting checking and action, making it a "plan-plan" control, or are we just acting without a definite plan, making it an endless "do-do" cycle?
- Are we appreciating valuable experiences and are lessons learned being transformed into standards?
- Is the PDCA cycle properly applied in annual targets? If problems are found in implementation, are they being resolved through reviews of targets and methods?
- Are production errors in routine jobs being remedied by stop-gap measures? Are we investigating errors to prevent recurrences?

The Shipbuilding Division is currently mobilizing its entire organization to implement TQC so that its concept, illustrated in *Figure 3-1,* becomes common knowledge of every employee. Survival cannot be guaranteed by just following traditional practices and TQC is the only means to renovate the concept of product quality and job quality. The following mottos apply:

- Our jobs should give first priority to satisfying customers. The old concept *of product-out* which gives more attention to producers should be changed to *market-in* which gives more attention to customers.
- . In solving problems in a routine operation, modesty and frankness are required in seeking problem causes. In other words, in judging a cause, each one must think of personal responsibilities rather than other's.
- The world contains much knowledge unknown to ourselves. It is essential to learn and educate ourselves to expand our knowledge.
- We are apt to feel self satisfied when a job is going well without problems. This attitude precludes true improvement.

3.3 *Operational Organization of TQC in IHI*

3.3.1 The TQC Organization in IHI and its Outlet

Small Group Activity in IHI started around 1966, and each shipyard had its own policy and methods. A typical example is shown in *Figure 3-2.*

To assist the General Manager to promote Small Group Activity, an executive office was established with a full-time staff engineer in each yard. Some offices, depending on a shipyard's size and work volume, also had fill-time clerks.

In 1970, the first meeting of these offices was held to exchange information. Since then and until about 1980, such meetings were held in different shipyards. After that, a central Production Technology Development Office was established in corporate headquarters to manage TQC activity on a company basis. Then, coordinated meetings were held for stories of actual experiences of small group activities in all yards and works. In 1985, meetings began to be conducted division by division, e.g., for the Shipbuilding Division, only shipbuilding experiences were discussed. This change reflects an appreciation of the uniqueness of each division's policy and management methods. In order to strengthen TQC activity at the same pace throughout the company, representatives from each yard and works meet twice per year to present their experiences and exchange information.

Further, as QA/QC requires an organized and well planned movement to satisfy customers' needs by types of products, the quality *assurance* function was established at division headquarters and the quality *control* function was established where the products are being manufactured. For IHI shipyards this approach is more effective because marketing and basic design are division responsibilities. Close ties are maintained between the latter and production functions so that quality can be perfectly controlled through the stages for sales, planning, design, production and after delivery. The Quality Assurance Department at division headquarters reports to the division General Manager in a staff capacity. This department participates in policy making, and plays a role to establish, maintain and/or improve the division's quality assurance structure.

The Quality Control Department in each shipyard governs the quality control activity including inspection, starting from detail design to production and, finally, until the guarantee period ends. When the guarantee period expires, it also acts as a center to take care of after sales services to complete quality assurance activity. Therefore, the Quality Assurance Department plans and promotes TQC under the instructions of the Division General Manager, and the Quality Control Department in each shipyard exerts efforts to plan and promote TQC at production sites.

3.3.2 The *Role of Management*

Sometimes, we hear some managers complain, "I'm so busy that I can't spare any time for small group activity." This is not right because a manager's job is to materialize ideas through workers, and to motivate, educate, and upgrade capabilities of workers. As small group activities are a means to foster the talents of people, management should devote time to promoting them and create an atmosphere which gives opportunity to subordinates to utilize their capabilities to the maximum extent.

ORGANIZATION AND ASSIGNMENT OF 3Z MOVEMENT

ORGANIZATION	CONSTRUCITON	DUTY	FREQUENCY OF MEETINGS
PROMOTION COMMITTEE 3Z SECRETARIAT	CHAIRMAN WORKS MGR. DEPUTY WORKS MGR. MEMBERS EACH DEPT. MGR. LABOR UNION REPS. 3Z SECRETARIAT	1) SETTING OF WORKS POLICIES. 2) REVIEW OF EACH DEPT REPORT ON MOVEMENT & OF PROBLEM POINTS. 3) FINAL DECISION ON VARIOUS KINDS OF AWARDS. 4) DECISION ON DISTRIBUTION OF BUDGETS RELATED TO 3Z MOVEMENT.	ONCE/MONTH
3Z LIAISON MEETING	RESPONSIBLE PARTY DEPUTY WORKS MGR. MEMBERS: EACH DEPT. REP. 3Z SECRETARIAT	1) REVIEW OF GROUP AWARDS (COMPETENCE PRIZE OR OVER) IMPROVEMENT SUGGESTIONS (GRADE B OR OVER) AND OTHERS. 2) ITEMS OF 3Z LIAISON CONCURRENTLY RELATED TO EACH DEPT.	WHEN NECESSARY
DEPT. COMMITTEE MEETING	CHAIRMAN DEPT. MGR. MEMBERS: EACH SECT. MGR.	1) SETTING OF DEPT. POLICIES. 2) REPORT OF PROMOTION COMMITTEE. 3) REVIEW OF EACH SECT REPORT ON MOVEMENT & OF PROBLEM POINTS. 4) REVIEW OF AWARDS SUBMITTED BY EACH SECT. 5) REVIEW OF EDUCATION PROGRAMS.	ONCE/MONTH
SECT. COMMITTEE MEETING	CHAIRMAN SECT. MGR. EACH STAFF MEMBER IN CHARGE. MEMBERS EACH FOREMAN EACH GROUP LEADER	1) SETTING OF SECT POLICIES. 2) REPORT OF DEPT. COMMITTEE. 3) REVIEW OF REPORT ON MOVEMENT OF EACH JOB AREA (EACH GROUP) & OF PROBLEM POINTS. 4) REVIEW OF GROUP AWARDS AND IMPROVEMENT SUGGESTIONS. 5) STUDY ON EDUCATION PROGRAMS.	ONCE/MONTH
VARIOUS KINDS OF MEETINGS	RESPONSIBLE PARTY STAFF MEMBER IN CHARGE FOREMAN MEMBERS: RELATED GROUP LEADER RELATED GROUP MEMBER COORDINATOR SECT. MGR.	1) STUDY ON THE MANNER OF PROCEEDING WITH JOBS THROUGH OPERATIONAL PROCESS MEETING, SAFETY MEETING, ETC. 2) TRANSMISSION OF SECT POLICIES & .STUDY ON GROUP **MEETING POLICIES.** 3) REVIEW OF PROBLEM POINTS OF A GROUP. 4) SELECITON FOR GROUP COMMENDATIONS& IMPROVEMENT SUGGESTION AWARDS.	WHEN NECESSARY
3Z GROUP MEETING	RESPONSIBLE PARTY: GROUP LEADER MEMBERS: EACH GROUP MEMBER COORDINATORS: SECT. MGR. STAFF MEMBER IN CHARGE FOREMAN	1) SETTING OF TARGET ITEMS & TARGET VALUES. 2) ENGINEERING FOR THE PURPOSE OF TARGET VALUES ACHIEVED. 3) TRANSMISSION OF POLICIES OF THE SUPERIORS. 4) GROUP DISCUSSION ON 3Z SUGGESTIONS. 5) CONTRAST AND STUDY ON PREDICTION AND REALITY. 6) CONFERENCE ON OPERATIONAL PROCESSES.	TWICE OR OVER/MONTH (WHEN NECESSARY)

FIGURE 3-2: An Example of Organization of Small Group Activity

The role which management should play could be summarized as:

. Fertilize so that the small group activity can grow. Managers have to show keen interest in small group activities and remove obstacles which hamper them.

- When setting policy and targets for small group **activities, it is** important to make clear what the policy and targets are and, to make clear what is expected in QCC activity for solving significant problems.

- The small group activities must be properly assessed. QCC activity is not simply a movement for improvement. What is important is the problem solving procedure and its potential. It is essential for management to assess activity accordingly.

- Management should periodically attend routine small group meetings in order to find out whether group members are really participating, satisfied with their progress, etc.

Probably most important is support given **to** group leaders. Middle management must be conscious of their roles to relay top policy downwards and routine QCC achievements upwards. This means that middle managers must maintain a working relationship with subordinates in order to achieve full output of groups when challenging targets and preparing proposals for improvements.

3.3.3 *Roles of a QCC Executive offfice*

The important role of the QCC Executive OffIce is to assist a yard General Manager in promoting QCC activity within and coordinating TQC activities outside the yard. More specifically, the office:

- prepares promotion plans, event plans, budgets for QCC/TQC activities, etc.,
- prepares education plans (seminars, selection of text books, etc.),
- produces guidance manuals for QCC/TQC operations, prepares documents, forms, **etc.,**
- records statistical data, makes reports, keeps records of proposal reward applications, etc.,
- publishes a yard QCC/TQC magazine, advertises slogans, prepares posters, etc.,
- solves complaints from various shops, groups, etc.,
- plans and conducts QCC exchange meetings, presentation meetings, etc.,
- assists top management to diagnose the group activities, etc., and
- counsels group leaders to help them to set targets, make reports, etc.

Personality traits required for executive office people are:

- initiative based on strong faith,
- power and ability to plan, express opinions, persuade people, etc.,
- ability to make good judgments on conflicting matters.

Diagnosis by top management is aimed at assessing, from a company-wide viewpoint, how policy is spreading downstream, how it is being executed, and what is being achieved. Problem areas are identified and, if possible, rectified through policy adjustments. The diagnosis, through brief audit reports, provides management's assessments of achievements to persons concerned. Each diagnosis is also important for presentation during meetings held to demonstrate top management's enthusiasm to continue promotion and follow-up of further QCC/TQC activity.

Figures 3-3 (a) through 3-3 (b) shows typical information compiled and distributed by a QCC executive office.

3.3.4 *TQC Activity in a Sales Department*

In sales, their business is apt to be rather unforeseen, and people are often too busy in solving problems instead of spending **time to** plan and execute their jobs. Further, they are usually required to make quick decisions within a short time period to cope with changes in market demands. Sales job features do not appear to match with TQC activities. However, there are still many repetitive special jobs for which productivity could be enhanced.

A sales department requires a long term strategy to be competent in the market. Therefore, sales has the responsibility to establish a policy to select and determine what products should be sold, and how the products should be sold. Accordingly, the aim of TQC in sales is to review each individual's job, investigate changes in market situations, customers' demands, competitors' moves, etc., to exert effort to analyze and discover the company's advantages and disadvantages, and find the best strategies and tasks to strengthen the company.

Sales plays the important role to feed results of market studies to basic design for the purpose of developing products which will meet future market demands. Especially under growing economic circumstances, the concept of "market-in" is very important. More effort should be made to maintain contact with customers to identify their needs and to pursue new products that meet those needs. It is necessary for sales people to participate with potential customers at their planning stages to help them analyze and design alternatives for ships and end products other than ships.

An essential sales role is to contribute to increases in profitability by generating more revenue through increased orders and/or increased prices. When results are poor, causes must be analyzed so that remedial measures can be taken. On the other hand, if results are good, the processes that led to success should be standardized to establish bases for future sales activity.

Thus, the policy of top management in the sales department is to require discussions and conclusions on the following subjects through small group activity:

- Aggressive investigations on the selection of strategic products.
- Accurate analyses of market trends and demands, and how to evaluate data collected.
- Production of guidance manuals for sales jobs that could be standardized so that more time can be spent in planning and executing.
- Analyses on estimated costs vs. contract prices and actual completion costs to establish sales strategies for future projects.

3.3..5 *TQC Activity in a Basic Design Department*

The achievement of basic design is known only after a product (ship, offshore structure, etc.) has been in a customer's service for some time. Basic design must work with sales as a unit to constantly grasp customers' and/or market needs, and develop products that satisfy such needs.

important targets for enhancing productivity of a basic design department are:

- Reduce guarantee service costs which are caused by deficiencies in design.
- Strengthen competitiveness by reducing product cost through value engineering.
- Secure each customer's confidence by enhancing design quality.
- Promote reasonable rationalization of design features, i.e., bring more logic into design (e.g., anticipate straight pipe runs that will permit a greater percentage of straight pipe pieces and use of common supports).
- Upgrade the quality of improvement proposals and activate them in design.
- Imrove accuracy in cost estimating and complete the Basic Material List (BML) for each-project at "an early stage.

In basic design, it can take several years after an end product is in service to complete the PDCA cycle and to establish improved design criteria and standards. Therefore, TQC in basic design must be systematized as an organization, rather than by individuals, to maintain analysis continuity.

3.3.6 *TQC in Detail Design Offices*

The detail design office in a shipyard is positioned between the basic design department and the production departments. Its responsibility is to provide detail information and instructions so that production people can construct the ship at a reasonable cost within a contract delivery date without interfering with specified functional and quality requirements. Designers in charge are required to assume that everyone outside of design is a customer in accordance with TQC philosophy. Designers must always take the standpoint of others, e.g., owners, producers, and operators.

Thus, designers have to thoroughly analyze feedback which describes how a ship is operating. When problems are described they work to find appropriate solutions to be implemented as guarantee work or to improve the quality of future products. This is obviously the PDCA cycle of TQC.

In IHI shipyards small group activity in detail design offices has developed along with such activity in production departments. At the beginning, activity was mainly in line with the ZD movement. However, it gradually took on design and standardization matters.

3.3.7 *TQC in Production Control Departments*

The function of a Production Control Department is to support smooth operation of a yard's production activities and to plan various rational methods to improve productivity. The following TQC approaches are given priority:

- Review whether present processes are best suited to satisfy the needs of others, e.g., buyers, suppliers, and subcontractors.
- For each work process, emphasize collecting good data from upstream and downstream processes.
- For recurring problems, make sure that facts are the bases for resolutions.
- Use the PDCA cycle incessantly and quickly respond to problems disclosed.

As TQC is a movement involving an entire manufacturing system, it must also involve subcontractors and suppliers. As such firms have unique characters, it is essential to guide them in implementation of consistent TQC measures. Some of the items requiring special attention are:

- Insure that suppliers and subcontractors understand why and for whom TQC must be exercised.
- Quality should not be compromised for the sake of a subcontractor. Guidance should be provided so that quality consistent with the shipyard's will be obtained.
- Insure that suppliers and subcontractors understand that the aim of TQC is to investigate problems in detail based on facts.

. As TQC is an activity based on participation and dialogue, encourage suppliers and subcontractors to speak out frankly.

. Manifestly appreciate their effort even though their targets and achievements may be comparatively small.

. Minimize requirements for control data and information to reduce management manhours, i.e., reduce such requirements to absolute essentials.

Examples of targets for a production control department itself are:

- Reduce manhours required for estimating change orders. The target set for the entire control department was to reduce its work by 30% through further rationalization. Use of a Pareto analysis disclosed to estimators that approximately 50% of their manhours were consumed in estimating change *orders.* Therefore, they established a target of 50% reduction in manhours for estimating change orders and began to rationalize their change order estimating routine. Costs for estimating change orders for 17 ships previously built, were analyzed. A Characteristic-Factor Chart was used to pinpoint problems which had to be addressed for improving change-order estimating productivity.

. Better control methods for Purchase Order Specifications (POS) issues and setting and adjusting scheduled material delivery dates. Current processes were broken down into distinct job units and the process for each job was reviewed and rationalized. The final results were documented as Business Rules (BRs) and a procedure was created for reviewing them every six months.

3.3.8 *TQC in Quality Control Departments*

The role of a Q/C department is to prepare a control plan in cooperation with engineering, production, production control (includes material management), and sales, and to incorporate the plan into each ship's construction plan. The control plan's purpose is to tailor a quality standard for each ship which is to be consistently applied by all departments. Therefore, TQC activity in a Q/C department is to perform inspections from the viewpoint of a customer's needs and to provide feedback to the departments, suppliers, and subcontractors concerned. Assessment of product grade is required at each stage or process, is fed back, immediately, so that improvement measures can be applied to following work. Thus, the PDCA cycle is operated constantly so that quality achieved becomes in agreement with quality required in the shortest possible time. Also, quality control procedures are reviewed when deficient products which affect the overall quality of a ship were overlooked during self-inspection by suppliers and particularly subcontractors.

3.3.9 *TQC in Production Departments*

The basic philosophy of TQC in a production department is to accomplish routine jobs, properly and as scheduled. In production, TQC is a comprehensive improvement activity covering all processes. Measures employed include control of policy, QC techniques, statistical analysis, etc. Innovation in thinking, understanding, and quickly reacting when problems are faced are necessary. Managers and supervisors are especially required to routinely examine production sites for potential improvements, so that jobs could be carried out more effectively and with less mental and/or physical strain. In solving a problem, a final solution is required instead of a stop-gap solution and a great deal of zeal is needed to achieve targets.

Production people usually have many problems to solve. Their problems relate to scheduling, work processes, accuracy, scrap percentages, usage of manhours and/or energy, etc. Regardless of the subjects, the common TQC concepts in production are:

- Improvement of management's philosophy: Management personnel are required to set up and control their own targets, devise tactics to achieve targets, and constantly think in terms of the PDCA cycle. Managers must have an eagerness to challenge problems and a system to grasp situations, extract problem causes, and apply the best solutions.

. Production engineering: In order to construct a ship of good quality at low cost and deliver it within the contract delivery date, elaborate pre-construction production engineering, based on feedback of problems encountered before or during construction, is essential.

. Audit system: No matter how good a policy or target is, it is impossible to manage and control every detail. An audit system is needed to constantly make improvements in quality level and to achieve the final quality target. The audit system must be structured so that the PDCA cycle is constantly applied regardless of change in personnel. This system should accumulate updated data and be refined incessantly.

. Control system through data: Management and control at production sites must be conducted based on data and various job manuals. As a matter of importance management must have an idea of how to use the data and how to connect the data to action. Whether or not data can be effectively utilized in along-term system depends on how thoroughly targets and output formats have been prepared by management.

. Small Group Activity: Many unexpected losses and subjects to be improved can be found in daily jobs which involve a great number of workers. But means to detect problems and to devise improvement plans are usually insufficient. When TQC techniques are utilized effectively, much more improvement proposals can be expected.

CLASSIFICATION & COMPARISON OF CONTENTS ACCORDING TO EACH FISCAL YEAR COVERING SUGGESTIONS MADE BY WELDING ASSY SECT.

AS OF AUG. ,1985 FISCAL YEAR						FOR THE CURRENT MONTH						AGGREGATE VALUE					
CLASSIFICATION OF CONTENTS	1980 55	1981 56	1982 57	1983 58	1984 59	1985	%	B	C	D	VALUE—LESS	1985	%	B	C	D	VALUE—LESS
FACILITIES; ENVIRONMENTS	% 4.7	% 3.1	% 2.3	% 3.1	% 8.0	61	18.1		34	26	1	453	14.5	1	316	127	9
JIGS, EQUIPMENT & TOOLS	14.7	10.9	52.9	32.8	24.0	66	19.6		49	16	1	747	24.0		507	233	7
FABRICATION & PROCESS	17 1	7.3	5.0	3.1	16.2	52	15.4		39	13	×	532	17.0		532	130	2
OPERATING METHOD	46.7	75.3	40.1	60.1	38.4	139	41.4		93	45	1	1257	40.4		863	367	27
SAFETY	18.2	4.0	0.2	0.8	13.4	18	5.4		14	4	×	126	4.0		69	53	4
(TOTALS)	9,407	1,423	102	454	1,850	336			229	104	3	3115		1	2155	910	49

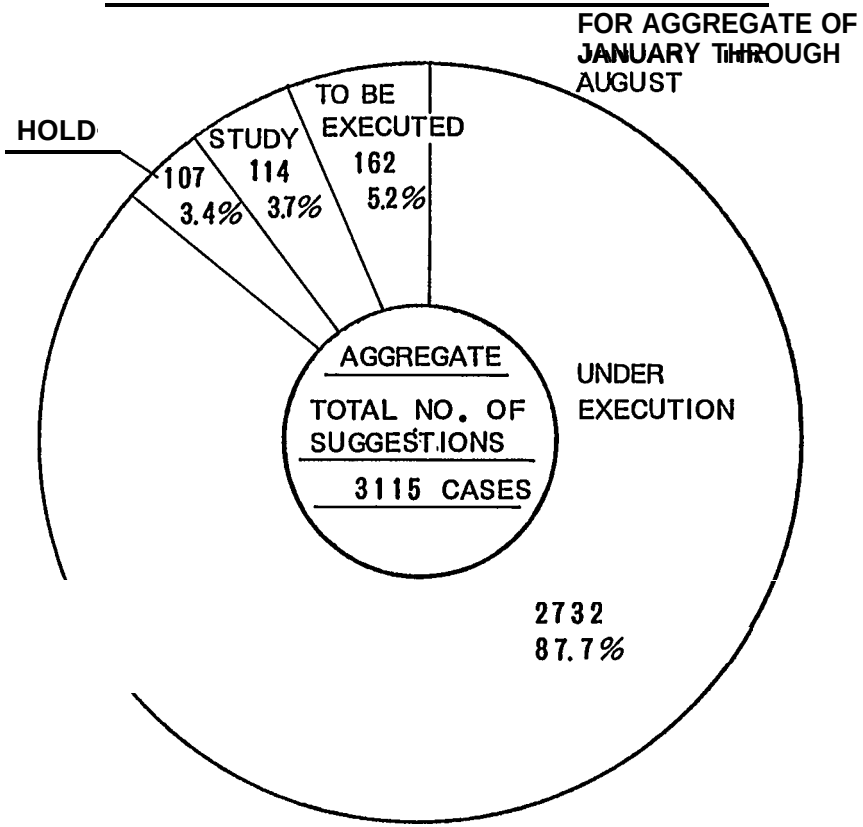
FIGURE 3-3(a): Typical information compiled by an IHI shipyard's *QCC* executive office,

AS OF RESULT OF FOLLOW-UP INVESTIGATION FOR SUGGESTION FOR
('AUG. ')IMPROVEMENT RELATED TO WHOLE SECT. AND TO JOB AREA

JOB AREA	FOR THE CURRENT MONTH					AGGREGATE VALUE				
	NO. OF IMPROVE-MENTS	UNDER EXECUTION	TO BE EXECUTED	STUDY	HOLD	NO. OF IMPROVE-MENTS	UNDER EXECUTION	TO BE EXECUTED	STUDY	HOLD
'HE WHOLE ;ECT	336	248	50	28	10	3115	2732	162	114	107
		73. 8 %	14. 9 %	8. 3 %	3. 0 %		87. 7 %	5. 2 %	3. 7 %	3. 4 %
2 W	99	82	12	3	2	865	734	45	50	27
		82. 8 %	12. 1 %	3. 0 %	2. 0 %		85. 8 %	5. 2 %	5. 8 %	3. 1 %
SUB	64	39	16	7	2	563	517	25	19	2
		60. 9 %	25. 0 %	10. 9 %	3. 1 %		91. 8 %	4. 4 %	3. 4 %	0. 4 %
SCAF— FOLD	19	15	3	1		147	139	7	1	
		79 0 %	15. 8 %	5. 3 %	%		94. 5 %	4. 8 %	0. 7 %	%
1 W	58	54		3	1	444	420		4	20
		93. 1 %	%	5. 2 %	1. 7 %		94. 5 %	%	0. 9 %	4. 5 %
1 A	62	31	17.	9	5	329	264	28	9	28
		50. 0 %	27. 4 %	14. 5 %	8. 1 %		80. 2 %	8. 5 %	2. 7 %	8. 5 %
2 A	34	27	2	5		767	649	57	31	30
		79. 4 %	5. 9 %	14. 2 %	%		84. 6 %	7. 4 %	%	3. 9 %
		%	%	%	%		%	%	%	%

FIGURE 3-3(b): Typical information compiled by an IHI shipyard's **QCC executive** office.

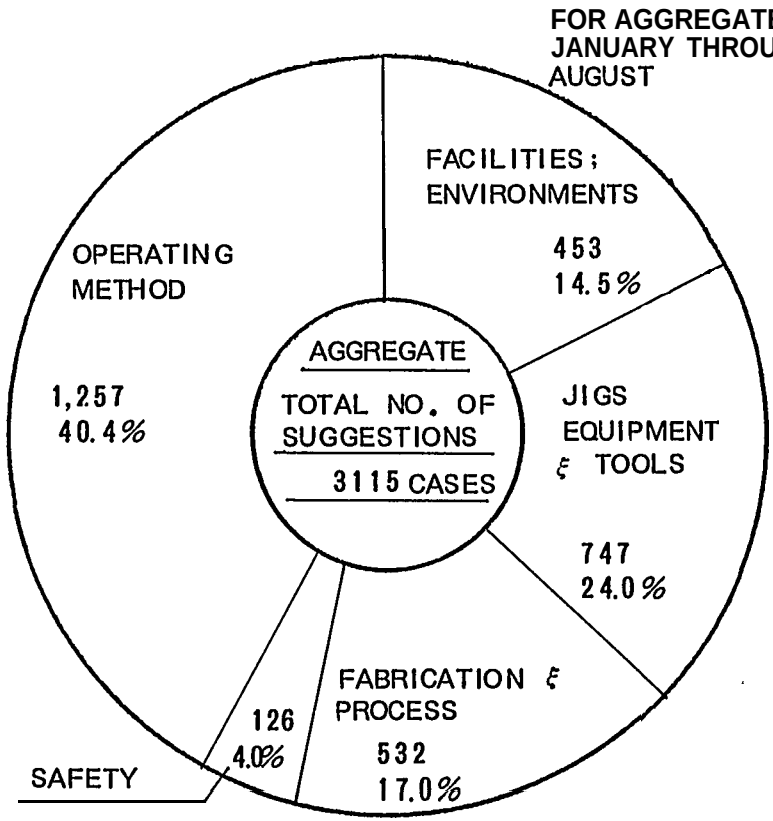
RESULT OF FOLLOW-UP INVESTIGATION FOR 3Z SUGGESTIONS



FOR THE MONTH OF AUGUST **ONLY**

UNDER EXECUTION	TO BE EXECUTED	STUDY	HOLD
248	50	28	10
73. 8%	14. 9%	8, 3%	3. 0%

RESULT OF COMPARISON FQR CLASSIFIED CONTENTS OF 3Z SUGGESTIONS



FOR THE MONTH OF AUGUST ONLY

FACILITIES ENVIRONMENTS	61	18.1
JIGS,EQUIPMENTIf TOOLS	66	19.6
FABRICATION & PROCESS	52	15.4
OPERATING METHOD	139	41.4
SAFETY	18	5.4
TOTAL	336	

FIGURE 3-3(c): Typical information compiled by an IHI shipyard's executive office.

THE WHOLE COMPANY INVENTIONS AND DESIGN APPLICATIONS
FILED FOR THE SECOND HALF OF FISCAL 1985

KURE NO. 1 PRODUCTION DEPT.
WELDING ASSY SECT.

NO.	JOB AREA	NAME OF IMPROVEMENT
1 ,	SCAFFOLD	DESIGN FOR SCAFFOLDING MATERIALS TEMPORARY INSTALLATION JIG
2	DITTO	DESIGN FOR LIGHT WEIGHT LADDER DEPOSIT JIG
3	DITTO	DESIGN FOR LADDER SLIP STOP JIG
4	DITTO	DESIGN FOR PLATE SECURING METAL
5	2W	DESIGN FOR THE AUTOMATIC BACK BURNING MACHINE RAIL ALIGNING RULE
6	DITTO	DESIGN FOR SLIDING TRANSVERSE RECEIVING JIG FOR FRAMEWORK
7	DITTO	IMPROVEMENT FOR MOVABLE CIRCULAR BLOCKS
s	DITTO	ARC TIMER COLLECTING DEVICE AND NAMEPLATE RACK
9	DITTO	$C0_2$ HANDLING DEVICE SECONDARY WIRING COLLECTIVE INSTALLATION DEVICE
10	DITTO	IMPROVEMENT FOR FCB BACKING BEAM TRANSPORTING CARRIAGE
11	DITTO	IMPROVEMENT FOR GAS CUTTING MACHINE TIGHTENING BOLTS
12	DITTO	IMPROVEMENT FOR FLAT OF 3K, FCB UNION SHOP
13	1A	STOWING FRAME FOR FALL PREVENTING STANCHION & ROPE
14	SUB	DESIGN FOR SNIP MEMBER EXTRUDING JIG
15	DITTO	DESIGN FOR GRAVITY SERVICING AUX. JIG (PART 1)
16	DITTO	DESIGN FOR GRAVITY DITTO (PART 2)
17	DITTO	DESIGN FOR GRAVITY OF CONFINEMENT SERVICE
18	DITTO	DESIGN FOR LARGE WIDTH PLATE RECEIVING ROLLER JIG
19	DITTO	DESIGN FOR TUBULAR SCAFFOLDING JIG
20	DITTO	DESIGN FOR GRAVITY RECEIVING JIG FOR PLATE
21	lW	CO_2 2 SETS FRAME TRANSVERSE RECEIVING & PLACING METAL IMPROVEMENT
22	DITTO	S2929-HA.HB COAMING RECEIVING JIG
23	DITTO	HIGH PLACE SERVICING SUSPENSION SCAFFOLD (FOR NARROW SPANS) IMPROVEMENT
24	DITTO	LONGITUDINAL INSERTION SLOT RECEIVING METAL IMPROVED
25	DITTO	HANGER STANCHION ACCORDING TO KINDS OF GAS HOSES, TIRES, AND WIRES
26	DITTO	FIX POINT JIG GRATING NOTCH IMPROVEMENT

FIGURE 3-3(d): Typical information compiled by an IHI shipyard's QCC executive office.

3Z SUGGESTION SUM UP TABLE (NOV.)

	NAME OF SECTION	A GRADE	B GRADE	C GRADE	D GRADE	① TOTAL	② NO. OF PERSON	①/②	NO. OF GROUP	AGGREGATE OF JAN. THROUGH NOV.
NO. 1 PRODUCTION DEPARTMENT	(1) CONTROL GROUP			1	1	2	10	0.20	1	16
	HULL FABRICATION S.			54	55	109	151	0.72	24	680
	WELDING ASSEMBLY S.			257	63	320	394	0.81	45	1,944
	ERECTION S.			43	121	164	330	0.50	36	938
	PIPE PIECE MANUF. S.		1	33	36	70	87	1.04	9	556
	HULL FITTING S.		2	194	250	446	267	1.67	27	3,100
	MACHINERY FITTING S.			10	21	31	155	0.20	16	474
	ELECTRIC FITTING S.			9	21	30	86	0.35	12	320
	PAINTING S.		2	77	19	98	85	1.14	11	318
	TEST AND TRIAL S.			1	2	3	41	0.07	7	57
	PRODUCTION ENGINEERING G.		1	11	2	14	16	0.38	1	65
	PRODUCTION CONTROL G.			2	5	7	10	0.70	1	63
	SUB TOTAL		6	692	596	1,294	1,632	0.79	190	8,531
NO. 2 PROD. DEPT.	(2) CONTROL GROUP				3	3	6	0.50	1	9
	DRIVING & HANDLING G.			13	24	37	81	0.46	12	189
	WORKING G.			39	23	62	96	0.65	12	383
	SUB TOTAL			52	50	102	183	0.56	25	581
SHIP REPAIR DEPT.	CONTROL GROUP			16	10	26	35	0.74	5	146
	HULL S.			39	35	74	135	0.55	20	622
	ENGINE S.			70	44	114	123	0.93	18	715
	DOCK S.		2	1	19	22	69	0.76	8	147
	REPAIR SHIP BUSINESS S.			1	6	7	7	1.00	1	29
	NAVAL VESSEL G.				9	9	9	1.00	1	30
	SUB TOTAL		2	127	123	252	378	0.67	53	1,689
SHIP DESIGN DEPT.	CONTROL GROUP			14	7	21	15	1.40	2	151
	DESIGN PROJECT G.			22	4	26	14	1.86	2	89
	HULL STRUCTURE D.G.			13	74	87	62	1.40	9	520
	DECK FITTING D.G.			10	38	48	45	1.07	5	359
	ACCOMMODATION FITTING D.G.			4	15	19	25	0.76	3	174
	MACHINERY FITTING D.G.		1	40	33	74	65	1.14	6	516
	ELECTRIC FITTING D.G.			6	23	29	28	1.04	4	175
	NAVAL VESSEL D.G.				5	5	6	0.83	1	38
	PROJECT G.			19	12	31	20	1.55	3	77
	SUB TOTAL		1	128	211	340	280	1.21	35	2,098
CONTROL DEPT.	CONTROL GROUP			1	3	4	8	0.50	1	19
	MATERIAL CONTROL GROUP			1	31	40	51	0.78	5	223
	PURCHASE GROUP			12	5	17	18	0.94	4	84
	SUB TOTAL			22	39	61	77	0.79	10	326
QUALITY CONTROL DEPT.				36	21	57	45	1.27	7	356
SALES BUSINESS DEPT.					9	9	19	0.47	3	58
SAFETY & SANITATION GROUP				1	14	15	24	0.63	3	116
SUB TOTAL				1	23	24	43	0.56	6	174
G. TOTAL			9	1,058	1,063	2,130	2,638	0.81	326	13,755

FIGURE 3-3(e): Typical information compiled by an IHI shipyard's executive office.

4.0 *EXAMPLES OF TQC*

4.1 Hierarchical Targets

4.1.1 Examples of TQC Targets in IHI

Presently activities earned out by all IHI employees are based on the company's policy to try everything that could strengthen the company's competitiveness and capabilities. This policy directs how the company should be operated and provides incentive for employees to exert their utmost efforts to achieve company targets.

The targets are, generally, given by the company as follows:

- Target: Improve profit by XX% over the present profit plan.

c Priority Targets:

- Reduce capital of inventory by XX%.
- Reduce losses caused by guarantee work and/or deficient work by XX %.
- Strengthen competitiveness by reducing production costs.
- Secure reliance from customers by improving quality.
- Improve productivity of indirect (white collar) jobs.

Based on the above company policy and targets, each division and yard establishes their own specific targets by breaking down the company targets into more specific control factors. The breakdowns continue hierarchically as shown in *Figure 4-1.*

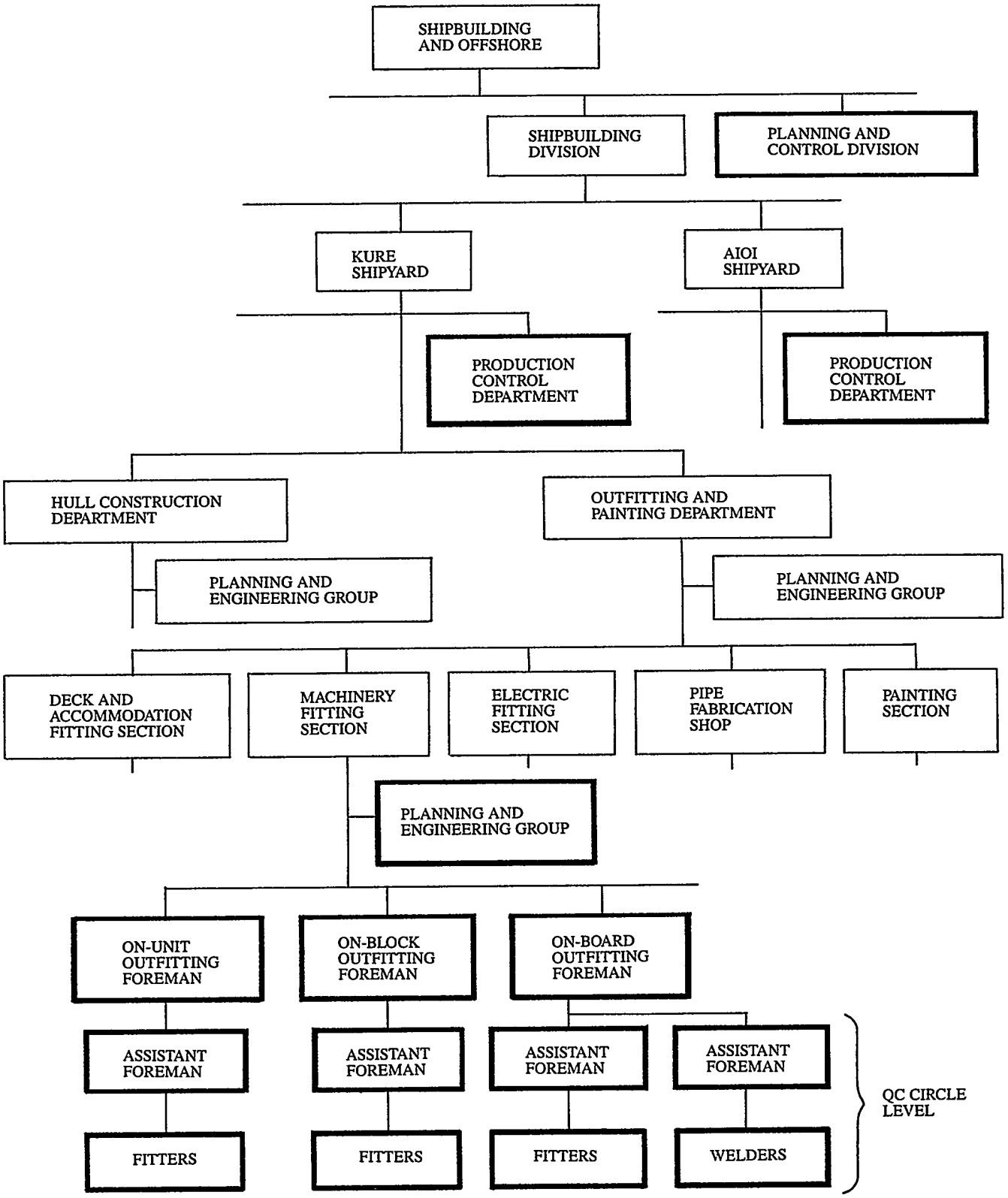
Typical examples of shipyard policy are:

Shipyard "A" Policy: Attain prominent improvement in accuracy. Build specified quality into the product.

- Priority Items:
  - Make sure production management and control techniques are being implemented.
  - Complete responses to feedback describing deficiencies.
  - Complete execution of QA/QC plans.
  - Promote further education of TQC.
  - Standardize work processes and jigs.
  - Estimate and analyze losses caused by manufacturing errors.
  - Establish a check system to be used by operators of large machinery both in the shipyard and in ships.
  - Improve measures to prevent missing material.

. Strengthening Competitiveness by Reducing Costs (achieve profit targets):

- Measures for reducing material costs by: promotion of VE for each ship, guiding and fostering special subcontractor shops, conducting cost analyses, promoting utilization of remnants, and reducing scrap percentage of steel material.
- Measures for reducing labor costs: eliminating lost time in integrated hull construction, outfitting and painting processes; fixing the position of work sites for jobs done on ground, and improving discipline so as to reduce idle time and rework.



NOTE: Bold boxes indicate the groups charged with actual formulation of the QC targets and personnel charged with implementation.

FIGURE 4-1: Breakdown of targets hierarchically.

- Measures for reducing general expenses: promoting saving activities in consumption of materials and energy, cutting material stocks, and reducing tool and equipment quantities.

- Create a team spirit at each work site through recreation challenges as well as work challenges.

- Reinforce engineering capability.

• Prepare Production Department plans:

- Technical Development: promote automation of welding in hull construction and outfitting, improve painting technology, analyze the production system and develop jigs and tools to enhance the system, and institute training/education programs for welders and painters.

- Machinery Operation: prepare operation manuals for various production machines and systems, prepare operation manuals for new machinery and equipment, and establish a trouble prevention system for each type of machinery and equipment.

- In-House Manufacturing: establish a system to check all production facilities for the purpose of maintaining them 100% operable, make clear schedule job-start dates utilizing sign-boards, analyze accuracy control measurement data by stages, review methods for controlling remnant material, and reduce X-ray disclosed weld effects to zero.

- Construction: establish and implement integrated schedules, establish a job control system to insure that the same jobs are performed at the same site, make the management control system very graphic so that someone can glance and understand, establish and implement standard work processes, purify work packages so that each contain work of only one problem classification, and establish a systematized process to use various stages, equipment and tools, e.g., real and virtual production lines.

- TQC Activity: establish standard work processes, establish a system to integrate hull construction, outfitting, and painting work, and set targets for numbers of improvement proposals, e.g., 1.2 proposals/ month/man.

Shipyard "B" Policy: Concentrate on improvement of accuracy and reduction in cost. The most important thing a shipyard can do is to construct a trouble-free, high-quality ship at a cost cheaper than what was predicted by top management. This means setting a target that is lower than top management's expectations and achieving the target.

• Specific Measures:

Activate and improve the efficiency of TQC activity by introducing QC techniques involving design, production control, subcontractors, and production as an integrated system.

Make full use of the new paint shop.

• Prepare Production Department plans:

- Restructuring to endure low output operation and diversified job requirements: acquire various techniques to increase the multi-functional capabilities of individuals, allow flexibility in operation and improve quality, and increase the speed of cost reduction measures.

. Targets:

Reduce costs: upgrade the CO_2 welding technique and achieve a welding rationalization effect of XX%, improve the quality of pieces and components by changing configurations if possible, reinforce individual cost control, and give full support to the technical development group.

Quality: reduce X-ray disclosed weld deficiencies to below X %, reduce cutting rework to XX% (make accurate assembly joints by improving accuracy at prior stages, evaluate the capabilities of workers and challenge them individually with targets to improve their abilities, and eliminate deficient products by fully employing QC functions).

Shipyard "C" Policy: Challenge to reduce costs. Concentrate on intensive engineering and challenge individual employees to reduce costs.

. Priority management and control items:

- Reduce XX% of budget cost.

- Reduce XX% of general expenses, etc.

. Prepare Production Department plans:

- Reduce cost by devising ways to improve from individual standpoints.

. Targets and Measures (Reduce XX% of the target at each process/stage):

- Complete and execute pre-construction engineering, i.e., engineering for each zone/stage of a build strategy.

- Improve field work performance, i.e., pick up problems and devise methods for improvement.

- Promote microscopic efficiency management and control. Make daily target clear for each individual and follow upon achievements.

- Stimulate small group activity, focusing on cost reduction.

- Promote rationalization of service work, i.e., review service workers' performances, such as for transportation, progress reporting, measuring, etc., to reduce their manhour expenditures.

- Improve the density of working hours, i.e., minimize waiting time.'

4.2 QC *Activity Report*

4.2.1 The *Status of Activity*

Although the basic direction of QC activity has been explained in Chapter 2.0, as time elapses, circumstances could justify some directional adjustments. The status of activities in IHI's Aioi Shipyard is taken as an example.

In 1983, Aioi Shipyard set up six targets based on basic policy promulgated by the Shipbuilding Division and common targets for IHI's five shipyards. This movement complied with the company's guideline to intensify TQC activity. The six targets were:

- reduce casualty frequency rates,
- step up cost reduction activity,
- activate small group activity,
- improve accuracy and product quality,
- reduce losses caused by guarantee work, and
- improve management control.

In Aioi Shipyard in 1984 there were 359 groups engaged in TQC through small group activity, challenging 400 targets. The targets could be classified as:

- Cost reduction, 56% of total.
- Improvement in productivity, 21 % of total.
- Quality assurance, 15% of total.
- Upgrade of technical skills, 4% of total.
- Others, 4% of total.

Even now in 1986, a group is a team organized to do work during a specific stage and its leader for QC is someone selected from the team. Also, some groups consist of two squads, e.g., one of fitters and another of welders, which jointly challenge a single target.

A group meeting is held for about one hour each month to discuss tactics, etc., and usually, the foreman, or sometimes a staff engineer, will join the meeting to provide guidance.

The substance of the meeting is reported in writing by the group leader and is endorsed by the foreman or staff engineer before it is sent to the shop/section manager. The shop/section manager enters comments on the report, which is then returned to the group.[z]

In most cases, a meeting is held by a single group, but if there are mutual concerns by the crane operators and/or riggers, for example, the meeting is held with more than one group involved. Decisions to have meetings are usually made by group members, and are sometimes suggested by a foreman or staff engineer.

A recent change in small groups in Aioi Shipyard is the fact that VE is being used as a tool to rationalize work processes. This trend is increasing and, consequently, staff engineers are often actively engaged in helping groups achieve their goals.

Before, staff engineers performed VE among themselves. They did not participate in small group activities. But, groups soon recognized that expertise was necessary and began to rely on the staff engineers more and more. Now it is part of a staff engineer's job to participate in small group activities.

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1 Actually, the first priority for all shipyard policies is to improve safety and health conditions. See the National Shipbuilding Research Program publication, "Product Oriented Safety and Health Management: May 1986.

2 The report format used is called a "Meeting Implementation Report." See Appendix A.

Due to the presence of staff engineers, almost half of the groups achieved their targets. Of the awards now given to the groups, 6% account for *excellent* prizes and *49%* for effort prizes. Also of the improvement suggestions submitted, 1% account for A or B grade, 25% for C grade and 74% for D grade. The number of suggestions were the highest in three years, averaging more than 1 suggestion/month/man. TQC activity in Aioi Shipyard was enhanced by adding VE to the QC techniques applied in the past. Managers are now quite convinced that their small group activities can challenge and, overcome any difficult circumstances that they may face in the future,

Supplementary information about small group activity in IHI's Kure Shipyard is contained in Appendix B which summarized responses to questions made by group leaders. Formats used by both shipyards are shown in Appendix A.

4.2.2 *Examples of Small Group Activity Reports*

An example of a Small Group Activity Report that was formally presented at the company's Small Group Presentation Meeting is shown in Appendix C. An additional twenty examples, prepared by group members, i.e., by workers, for various other types of work, are given in Appendix D.

4.3 Proposals for Improvement

4.3.1 Procedures to Handle Proposals/Suggestions

Proposals for improvement are powerful means to promote TQC activity. The number of proposals submitted per unit time is usually used as a gauge to assess the degree of QCC activities. Of course, it is a matter of opinion whether the *number* of proposals or the *quality* of proposals is more important. However, the *number* is sufficient because it shows the degree that group members are seriously taking part in increasing productivity.

The substance of proposals are basically in accordance with the shipyard, department, section or shop targets and in line with company policy. Proposal objectives usually include improvement of work environments, productivity, tools and jigs, production processes, methods, etc.

Various formats are used for proposals, but, at least, each format includes space to delineate the substance of the proposal, and, space for management comments. Adoption or rejection, suggestions for modifications, etc., are fed back to the proponent. The latter is important, not only for recording the results of appraisals, but, also, to encourage proponents by letting them know that their proposals were seriously reviewed by management.

The format also indicates the route which a proposal goes through, the name of the assigned reviewer if assessment by another department is required, etc., to clarify who or which section or department is responsible for the assessment.

As the majority of proposals are the result of group discussions, the proponents are represented by group leaders. In some cases, a report of a group meeting is used instead of a proposal format.

When a proposal is adopted, the scheduled date to implement the proposal is also indicated.

The appraisal consists of four grades, i.e., A, B, C and D (A is the highest) and, in order to assess the proposals fairly and objectively, standard assessment criteria are established. The point system consists of the following seven categories:

	Points
Creativity	0 - 5
Effort	0 - 5
Improvement expected	1 - 6
Applicability	1 - 6
Durability	1 - 6
Cost effect	2 - 7
Safety	1 - 4

There are some differences in points between production jobs and clerical jobs and/or between shipyards. By summing up the above seven scores, the appraisal grade is divided into the following ranks:

Grade	*Total Score*
A	above 21
B	17 - 20
C	13 - 16
D	8 - 12

The design department has a different score system which consists of the following three categories:

	Points
Effectiveness	1 - 4
Creativity	1 - 3
Effort	1 - 3

The appraisal grade is divided into the following ranks:

Grade	*Total Score*
A	10
B	8 - 9
C	6 - 7
D	3 - 5

However, point systems have a disadvantage because they do not express an absolute value such as a monetary amount, time percentage, etc. They are apt to yield different grades depending on individual scorers. Thus, scorers, in order to make judgements of various proposals on a more equal basis, have to consider:

- The saving effects on material cost and labor cost.
- Savings in design manhours.
- Improvement in functional performances.
- Effects which are difficult to measure with a scale.

The proposals submitted by group leaders go to a section or shop manager via a foreman. Most of the proposals are finally assessed, graded, and adopted or rejected by a section or shop level assessment committee. Those graded A and B are sent on for further review at the department level and the shipyard level assessment committee. Proposals which pass these reviews are sent to the company's headquarters committee.

The suggestion system for IHI's TQC movement is shown in *Figure 4-2.*

In the basic design office, design/engineering improvement proposals" graded A and B are submitted to the basic design office assessment committee once per month. The office manager acts as chairman, and all senior managers are assigned as committee members.

During the ten month period, from June 1982 through March 1983, the number of proposals for IHI's basic design office and the assessed grades were:

Grade	*Number of Proposals*	*Percentage (%)*
A	2 1	3
B	60	9
C	285	40
D	338	48

The average proposal rate was 0.61 proposals/month/man.

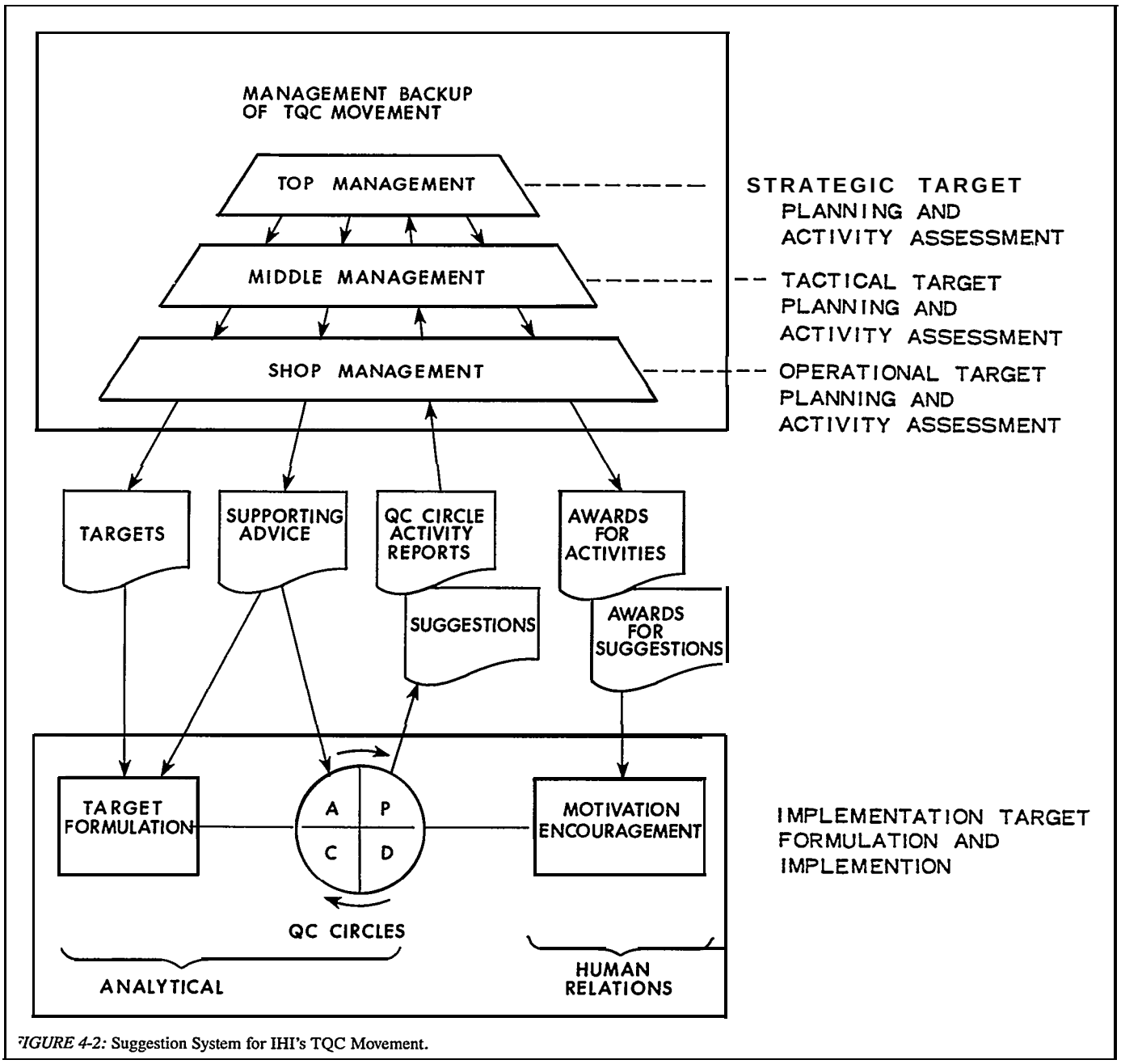


FIGURE 4-2: Suggestion System for IHI's TQC Movement.

5.0 PERVASIVE EFFECTS

5.1 QCC Activity and its Pervasive Effects

The basic philosophy of TQC is to have every employee of the company, from top management to workers, participate in QC activity involving sales, design, material management, etc., as well as production, to meet customers' needs which are becoming more and more diversified and sophisticated. By conducting QC as company-wide activity, a company can gain many advantages, such as, improving and stabilizing product quality, improving productivity, reinforcing the company's capabilities, increasing standardization, and raising the morale of employees.

Further, through TQC, the traditional management and control philosophy which, more or less, relied on opinion, gradually changed to a more rational and scientific approach which puts more emphasis on analysis of data. This enables management to give more precise and concrete guidance and instruction to their workers and, consequently, to get better response. But even in Japan, where TQC is practiced, there are complaints from some managers who feel that, by putting too much emphasis on data, management resiliency is being impaired. QCCs are primarily applied for improving the manufacturing system, but in doing so, they achieve quality improvement, cost reduction, and improved human relations, safety, etc., which cannot be ignored. Even though the idea did not arise from labor policies, respecting man's life and dignity is the basic spirit underlying QCC activity. Therefore, QCCs are appraised by their influence on small groups which led them to study and analyze facts, and their influence which led them to broadened and upgraded management and control capacity. Also, through QCC activity, the spirit of participation and spontaneity has been infused among employees. QCCs, as a management initiative, has raised the consciousness of people to participate and cooperate in group movements. In promoting TQC, it is most important to analyze what targets or goals should be set and what methodology would best suit the company's operation. When attention is paid to these considerations, experience indicates that TQC activity can be very successful.

The objectives of QCCs can be summarized as:

- To upgrade the leadership and management capabilities of production front-line supervisors.

. To raise the morale of production workers, and foster in them a spirit of participation and spontaneity concerning problem solving.

- To nurture capabilities to prevent recurrences of problems and the capabilities to standardize processes, determine check methods, control methods, etc.

- To eliminate problems by jointly using QC tactics with groups from upstream and downstream processes.

- To foster consciousness of constant problem seeking and improvement in management.

To achieve the above objectives, it is essential to:

. Dig out potential problems and solve them by utilizing the QC way of thinking. To do so, QC education for the entire organization is required.

- Let potential problems be exposed to and analyzed by various levels and viewpoints. This requires people to appreciate facts for evaluating what is right or wrong. For example, a quality product may cost more to produce, but often results in savings due to less rework and/or less guarantee work.

The positive effects of QCC activity are reflected back to the company when each individual finds work problems and tries to solve them as a matter of routine. This spontaneous response also develops human resources and contributes strength to the company.

The benefits of QCC activity, proven by experience in IHI shipyards, are:

- Better safety records.
- High quality and less claims.
- Employees have more consciousness in cost and quality.
- Employees become more eager to educate themselves. More suggestions for improvements are proposed.
- Better relationships between management and labor.
- Employees acquire more pride and confidence in their jobs.

5.2 *Precautions for Promoting QCCs*

There are potential pitfalls in promoting QCC activity. The following are typical problems that could be encountered:

- Extraordinary management skill is required to impose QCC activity as a *compulsory* top-down movement without destroying autonomous and spontaneous group behavior.
- Traditionalists will ask, "Why is QCC activity needed?"
- Unrealistic policies and targets will discourage workers.
- Inadequately trained group leaders can discourage group members.
- Inadequate time allowed for group activities can be interpreted as a management half-hearted effort.
- Small group activity not tied in with routine work will cause conflicts and/or confusion.
- Inadequate data will cause group activity to diminish.
- Themes that become meaningless can cause disinterest.
- Ambiguous QCC promotion activity can cause disinterest.
- Education is inadequate. It is said that QCC activity starts from education and ends with education, meaning that education must be repeated incessantly. Even after QCC activity has been introduced, it is sometimes necessary to enlighten all employees of what quality control is supposed to be, and re-educate them concerning the objective and necessity for QCC activity.
- Appraisal efforts are misdirected. The appraisal system for improvement proposals, should appreciate how a group is *challenging* routine problems, rather than just appraising its results. The appraisal effort should also recognize the individual who contributed most to a proposal.
- The attitudes of the managers may be problems. Managers and supervisors are very important in stimulating QCCs. As QCC activity is more or less endless, it is essential to constantly devise ways to encourage worker participation by management displays of sincerity, effort, zeal, and human respect.
- Top managers could be impatient. Top managers must be committed to avidly fostering QCC activity on a permanent basis with due regard for its analytical nature. Systems have to be put in place to collect good data; people have to be educated in analysis methods.

APPENDIX A
FORMAT SAMPLES

3Z SUGGESTION

	ENVIRONMENT (INCLUD. SAFETY)
	V E
	FEEDBACK
	JIGS & TOOLS
	OPERATION METHOD
	BUSINESS (RECORD)

SUGGESTION ENTERED DATE: . 19	RECEIVED: . 19	LEADER'S NAME		IMPROVEMENT SUGGESTION GRADE	A B C D
POSITION (SUBCONTRACTOR'S NAME)	GROUP NO.	NAME OF PERSON MAKING SUGGESTION		REFERENCE NO.	
TITLE (GIVE THE NAME OF TITLE SUITABLE TO THE MATTER YOU HAVE IN YOUR MIND.)					

CONTENT (DO NOT WORRY ABOUT WHAT KINDS OF LETTERS AND WORDS OF TEXT TO BE USED. THE CONTENT COUNTS. WRITE CAREFULLY SO THAT YOU MAY BE UNDERSTOOD WELL.)

CONTENT OF SUGGESTION

(PRESENT STATE)

(STEP OR STEPS TO BE TAKEN)

(EFFECTS)

CONTENT OF ACTION COVERING SUGGESTION

CREATIVENESS	
EFFORT LEVEL	
IMPROVEMENT LEVEL	
APPLICATION LEVEL	
DURABILITY	
ECONOMIC EFFECTIVENESS	
TOTAL POINTS	
21～23 POINTS	A
17～20 POINTS	B
13～16 POINTS	C
8～12 POINTS	D

SEAL OF DEPT. MGR.	SEAL OF SECT. MGR.	STAFF IN CHARGE	SEAL OF FOREMAN	SEAL OF LEADER	OTHER DEPT. & SECTS. CONFERENCE		
					SEAL OF DEPT. MGR.	SEAL OF SECT. MGR.	

DISPOSITION REPLAY		
ADOPTED	STUDY	HOLD
ESTIMATED IMPLEMENTATION	. 19	

NOTES)
1. THE PERSON MAKING SUGGESTION SHALL MAKE ENTRY ONLY IN SPACE ENCLOSED BY BOLD LINES, AND SUBMIT TO HIS GROUP LEADER.
2. GROUP LEADER SHALL SUBMIT TO HIS SECT. MGR. THROUGH THE ORGANIZATIONAL CHANNEL. SECT. MGR. SHALL DECIDE TREATMENT WITHIN TWO WEEKS, AND GIVE REPLY TO THE PERSON MAKING SUGGESTION. (ORIGINAL PAPER TO BE RETAINED BY THE SECT. MGR.)
3. SECT. MGR. SHALL REVIEW THE CONTENT OF SUGGESTION, AND IF IMPROVEMENT SUGGESTION IS INCLUDED, HE SHALL TAKE PROCEDURE STIPULATED SEPARATELY FOR APPLICATION FOR SUGGESTION SYSTEM.
4. GRADING FOR IMPROVEMENT SUGGESTIONS ARE CLASSIFIED TO GRADE A, GRADE B, GRADE C AND GRADE D.

3Z MEETING IMPLEMENTATION REPORT

GROUP NO.	

AFFILIATION SECT. JOB NAME OF LEADER	ATTENDANTS
, 19 (DAY)	FROM : HOURS TO : HOURS

ITEMS OF CONFERENCE AND ITEMS OF DECISION (TO BE ITEMAIZED)	DESCRIPTION OF SUPERVISOR		
	SECT. MGR.	STAFF MEMBER IN CHARGE	FOREMAN
MEETING OF NEXT TIME (TIME AND DATE, AGENDA) AND OTHER SPECIAL ITEMS			

CAUTIONS	
	(1) GROUP LEADER WILL, RELATIVE TO GROUP ACTIVITIES, PAY ATTENTION TO THE FOLLOWING POINTS AND HAVE THE MEETING IMPLEMENTED. (2) GROUP LEADER IS THE PLANNER OF A MEETING AND THE CHAIRMAN. UTILIZE THE MEETING EFFECTIVELY. BEFORE MEETING, CHECK WHETHER PREPARATIONS ARE SUFFICIENT. (3) MANAGE THAT ALL MEMBERS WILL PRESENT THEIR OPINIONS RESPECTIVELY, AND DESIGN HOW TO PRESENT PROBLEM POINTS. (4) USE CONSIDERATIONS SUCH THAT LOTS OF OPINIONS AND SUGGESTIONS RELATED TO IMPROVEMENT OF JOBS WILL BE PRESENTED. (5) IF IN TROUBLE, CONSULT YOUR SUPERIOR AND DESIGN COMMUNICATION.

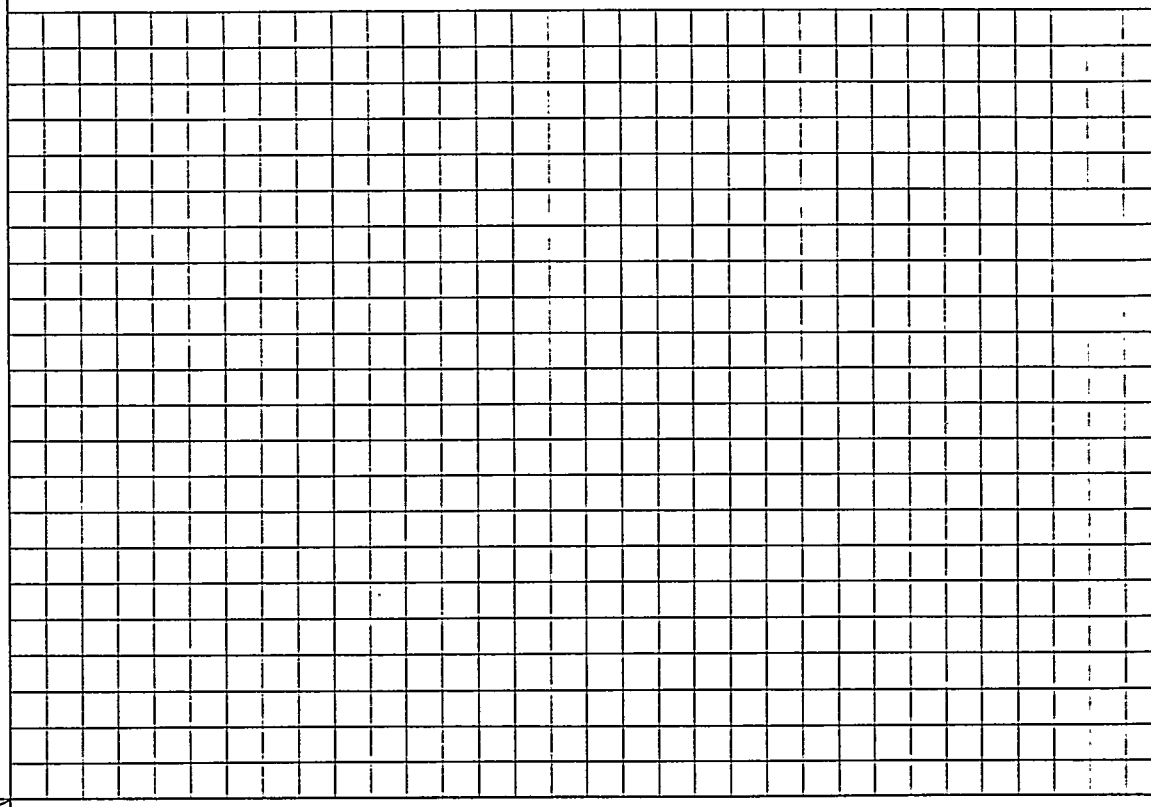
32 IMPLEMENTATION PLANNING SHEET

AFFILIATION	GROUP NO.	NO. OF MEMBERS	W OF GROUP LEADER	S M	s	F
DEPT. SECT. JOB						

TARGET ITEMS

NAMES OF MEMBERS

S NO. TIME SPAN CURVE ..... PLAN ——— ACTUAL RECORD



TIME SPAN / MO. DAY

ESTIMATE & ACTUAL RECORD CONTROL	MO. / ITEM					PAST ACTUAL RECORD	S NO.		REMARKS
	AMT. OF MATERIALS						AMT. OF MATERIALS		
	EFFICIENCY						EFFICIENCY		
	PLANNED MANHRS						PLANNED MANHRS		
	ACTUAL MANHRS						ACTUAL MANHRS		
ENGAGEMENT RATE	PLANNED/ ACTUAL								
SUGGESTION	PLANNED/ ACTUAL								
SAFETY PERFORMANCE									

OPINION OF AFFILIATION CHIEF

3Z GROUP COMMENDATION APPLICATION SHEET

PREPARED: , 19

DEPT. SECT. JOB	STARTED/ DATE FINISHED		DEPT. MGR.	SECT. MGR.	STAFF MEMBER IN CHARGE	FOREMAN	GROUP LEADER
	START						
(SUBCONTRACTOR'S NAME)	FINISH						

NAME OF GROUP LEADER	GROUP NO.	NO. OF MEMBERS	NAMES OF GROUP MEMBERS

TARGET	TARGET ITEM	EVALUATION MEASURE	ACTUAL RECORDS	TARGET VALUE

ITEMS DESIGNED AND/OR IMPROVED AND SPECIAL ITEM

OPINIONS OF SECT. MGR., STAFF MEMBER IN CHARGE AND FOREMAN

CAUTIONS

(1) COMMENDATION WILL BE DETERMINED BASED ON THE OVERALL EVALUATION AMONG GROUPS ACHIEVING TARGETS RELATED TO DEGREE OF IMPROVEMENT TREATMENT DURING PROCESS OF ACHIEVEMENT, EFFECTIVENESS, SUGGESTION RATE, SAFETY PERFORMANCE, ENGAGEMENT RATE AND DEGREE OF EFFORTS. ALSO, IN CASE NO TARGET HAS BEEN ACHIEVED DECISION MAY BE POSSIBLE BASED ON EVALUATION OF OTHER FACTORS.

(2) THE COMMENDATION WILL BE DIVIDED INTO THE THREE CLASSES OF EXCELLENCY PRIZE, SUPERIORITY PRIZE AND EFFORT PRIZE. THE EXCELLENCY PRIZE AND THE SUPERIORITY PRIZE WILL BE AWARDED BY DELIBERATION AND DECISION MADE BY THE 3Z LIAISON COUNCIL.

(3) WHERE NO TARGET VALUE AND NO ACTUAL RECORDS CAN BE EXPRESSED IN NUMERICAL VALUES, MAKE THEM EXPRESSED BY WORDING.

- THE GROUP LEADER SHALL MAKE ENTRY FOR SPACE ENCLOSED BY BOLD LINES ONLY, AND MAKE SUBMITTAL TO SECT. MGR. THROUGH JOB ORGANIZATIONAL CHANNEL.
- THE 3Z SECRETARIAT OFFICE SHALL BE SUBMITTED WITH FOUR COPIES.

SHEET (A) | NO. | PREPARED: , 19

SMALL GROUP VOLUNTARY CONTROL - ACTIVITIES IMPLEMENTATION PLANNING SHEET	RECEIVED FOR REGISTER	AT THE TIME TARGET SET

DEPT.	SECT.	JOB AREA	NAME OF LEADER	GROUP MEMBERS
				PERSONS

NAME OF GROUP	TARGET	OPERATION CONTENT

NAMES OF GROUP MEMBERS	AT THE TIME TARGET SET		
	EVALUATION MEASURE	PAST ACTUAL RECORD	TARGET VALUE

	ITEM \ MONTH	ACTIVITY PROMOTION DEGREE	ESTIMATED PERIOD	IMPLEMENTED PERIOD
1	TARGET SET			
2	STATUS ANALYSIS			
3	CAUSE ANALYSIS			
4	COUNTERMEASURES			
5	IMPLEMENTATION			
6	ACIEVEMENT AND EFFECTS GRABBED			
7	PREVENTIVE MEASURES			

COUNTERMEASURES (WHAT IS THE SHARE OF ROLES OF THE LEADER AND THE GROUP MEMBERS ?)

: ACTUAL RECORD GRAPH

SHEET ©

※ THE SUPERIOR WILL CHECK MONTHLY AND ENTER HIS ADVICE. (/)

TARGET CHALLENCE PROMOTION SHEET

GR NO.		G/L	
TARGET			

STEP NO.	DATE OF ENTRY	STEP ITEM CAUSE AND SETTLEMENT	CONTENT	PARTY MAKING ENTRY CHECK OR SEAL

TQC MOVEMENT ACTIVITIES

REPORT SHEET PREPARED: , 19 GROUP

REASONS FOR PICKING UP THE TARGET, PROBLEM POINTS INVOLVED AND CAUSES THEREOF

IMPLEMENTED COUNTERMEASURES

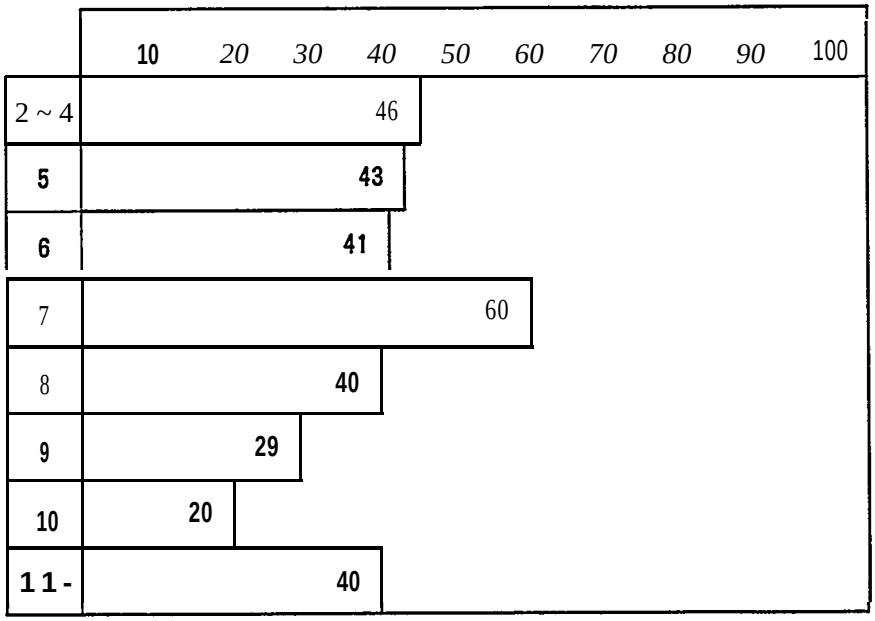
EFFECTS AND PREVENTIVE METHOD
(PROBLEMS STILL PENDING AND COUNTERMEASURES FOR THE FUTURE)

THE PRESENT SITUATION OF THE 3Z ACTIVITY
(FROM THE QUESTIONNAIRE TO THE GROUPS LEADERS)

THE NUMBER OF GROUPS (THE NUMBER OF ANSWERS) =319

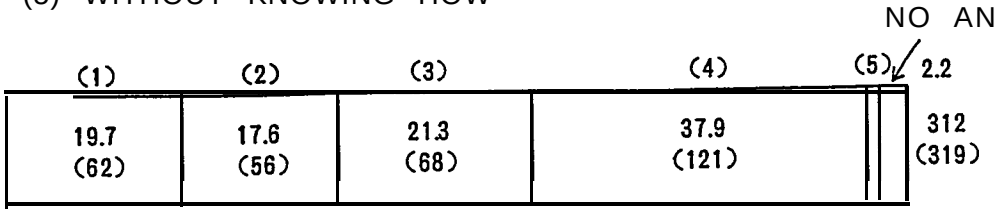
Q.HOW MANY PEOPLE ARE THERE IN YOUR GROUP?

ANS .



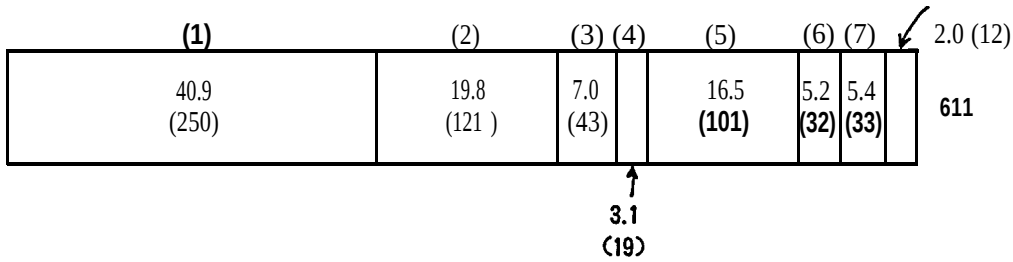
Q.HOW DID YOU DECIDE THE PRESENT GOAL IN YOUR ACTIVITIES?

ANS .
(1) **BOSS'S OPINION**
(2) MEMBER'S OPINION
(3) GROUP LEADER'S OPINION
(4) DISCUSSION AMONG MEMBERS BOSS'S ADVICES
(5) WITHOUT KNOWING HOW



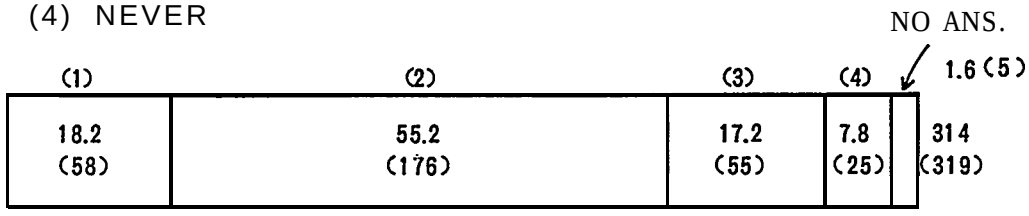
Q. ON WHAT POINTS DO YOU **FOCUS IN DECIDING THE** GOALS OF YOUR GROUP?

ANS. (1) WORK EFFICIENCY
(2) QUALITY OF WORK
(3) THE TIME OF DELIVER
(4) IMPROVEMENT OF MORAL
(5) SAFETY OF WORK
(6) REDUCTION OF PRODUCING COST
(7) ESTABLISHMENT OF **PRODUCTION MANAGEMENT SYSTEMS**



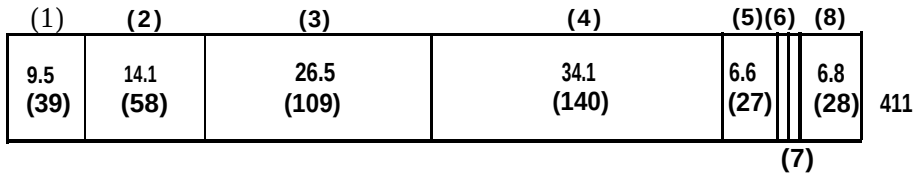
Q. AT THE **BIGINING OF** YOUR GROUP ACTIVITIES, DO YOU RECOGNIZE THE STATUS QUOTE THROUGH **ANALYZING DATA OBJECTIVELY WHICH** ARE COLLECTED IN YOUR DAILY WORK?

ANS. (1) ALWAYS
(2) ALMOST
(3) SOMETIMES
(4) NEVER



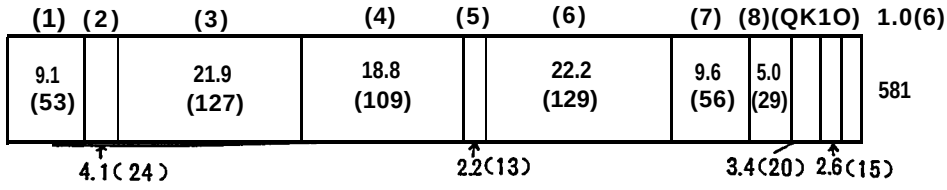
Q. (TO PEOPLE WHO CHOOSE (1) OR *(2)* **OR** (3) IN THE PREVIOUS Q.)
WHAT **KINDS OF METHOD DO YOU USE IN ANALYZING THOSE DATA?**

ANS.
(1) PARETO DIAGRAM
(2) CHARACTERISTIC-FACTOR DIAGRAM (FISH BONE DIAGRAM)
(3) CHECK SHEET
(4) GRAPH
(5) PROCESS CONTROL DIAGRAM
(6) DIAGRAM WITH KJ METHOD USED
(7) SYSTEMATIC DIAGRAM
(8) ETC.



Q. WHAT SORTS OF MERIT CAN FIND IN THE 3Z ACTIVITY?
(TWO ANSWERS PER A HEAD)

ANS. THE **3Z ACTIVITY ENABLES YOU.**
(1) TO DEVELOP YOUR SKILL AND KNOWLEDGE.
(2) TO DISPLAY YOUR OWN ORIGINALITY AND ABILITY.
(3) TO DEEPER MUTUAL UNDERSTANDINGS AMONG YOUR GROUP MEMBERS.
(4) TO DEEPER COMPREHENSION AS TO YOUR JOB.
(5) TO TAKE CONFIDENCE IN YOUR JOB.
(6) TO WORK WITH SAFETY , EFFICIENCY AND THOROUGHNESS.
(7) TO HAVE GOOD TEAM SPIRIT WITH CO-WORKERS AND A BRIGHTER WORKING ENVIRONMENT.
(8) TO CULTIVATE LEADER-SHIP IN YOUR GROUP ACTIVITIES.
(9) TO RECOGNIZE YOUR ROLE AND RESPONSIBILITY CLEARLY IN YOUR JOB.
(10) TO GET POSITIVENESS TOWARD YOUR JOB BECAUSE OF ITS INDEPENDENT POLICY.



APPENDIX C
An Example of a Small Group Activity Report

INTRODUCTION OF GROUP

THEME OF PUBLICATION	QC ON ELECTRICAL OUTFITTING WORK			
BELONGS TO	AICHI YARD PRODUCTION DEPT. ELECTRICAL OUTFITTING SECT.			
NAME OF PERSON MAKING PUBLI-CATION	KAZUHEI MIMURA		JOB POSITION	GROUP LEADER
NAME OF GROUP	MIMURA GROUP	NO. OF GR. MEMBERS	5	
GROUP STARTED	APR. 1982	PERIOD OF SOLUTION OF THEME	6 MONTHS	

INTRODUCTION OF THE DUTY OF THE GROUP:

MIMURA GR. IS ONE OF GROUPS BELONGING TO THE ELECTRIAL OUTFITTING SEC., AND PERFORMS OPERATIONAL ADJUSTMENT FOR ALL ELECRICAL OUTFITTING AND INSTRUMENTATION EQUIPMENT OF REPAIR SHIPS, PLANTS, OFF-SHORE STRUCTURES, ETC. THIS GROUP STARTS ITS ACTIVITIES ABOUT THE TIME WHEN A PROJECT IS NEAR TO COMPLETION. IT PLAYS THE ROLE OF MAKING OVERALL CONFIRMATION OF OPERATION OF MOTORS AND SWITCHBOARDS FIRST OF ALL, AND PERFORMANCE OF VARIOUS KINDS OF ALARM DEVICES, INSTRUMENTATION EQUIPMENT, ETC., AND DELIVERING THEM TO CUSTOMERS. ACCORDINGLY, THE HIGH LEVEL TECHNICAL SKILLS OF THE GROUP GAINS TRUST OF CUSTOMERS. THE GROUP TAKES A GREAT PRIDE IN ITS REPUTATION.

THEME

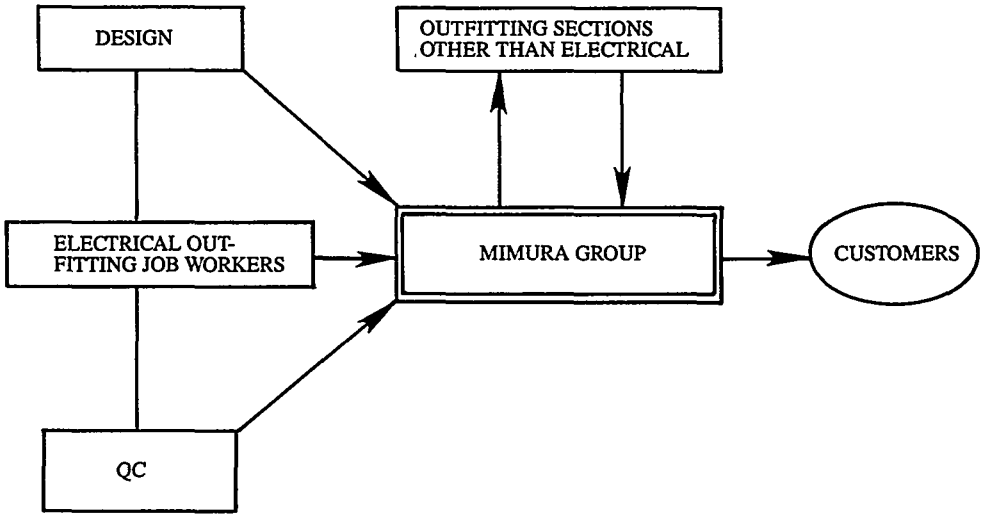
THOROUGHGOING QC ACTIVITIES FOR THE
ELECTRICAL OUTFITTING SECTION

GROUP ORGANIZATION:	
GROUP MEMBERS	5 PERSONS
AVERAGE AGE	36 YEARS

CONTENTS OF OPERATION OF MIMURA GROUP

REPAIR SHIPS
PLANTS
OFF-SHORE STRUCTURES

} OPERATIONAL ADJUSTMENT



REASON FOR THE THEME SELECTED

SECT. MANAGER'S POLICY

OUT AND OUT WINNING
ELECTRICAL OUTFITTING.

THE QUALITY OF VARIOUS KINDS OF MACHINERY AND HIGH GRADE MECHANISMS } IS ASSURED.

- SAFETY
- HIGH EFFICIENCY
- LOW COSTS

} → DELIVERED TO CUSTOMERS.

TARGET VALUES

1. SAFETY

ZERO ACCIDENTS

2. WITNESS INSPECTION

ACCEPTANCE RATE

100%

3. MAN-HOURS

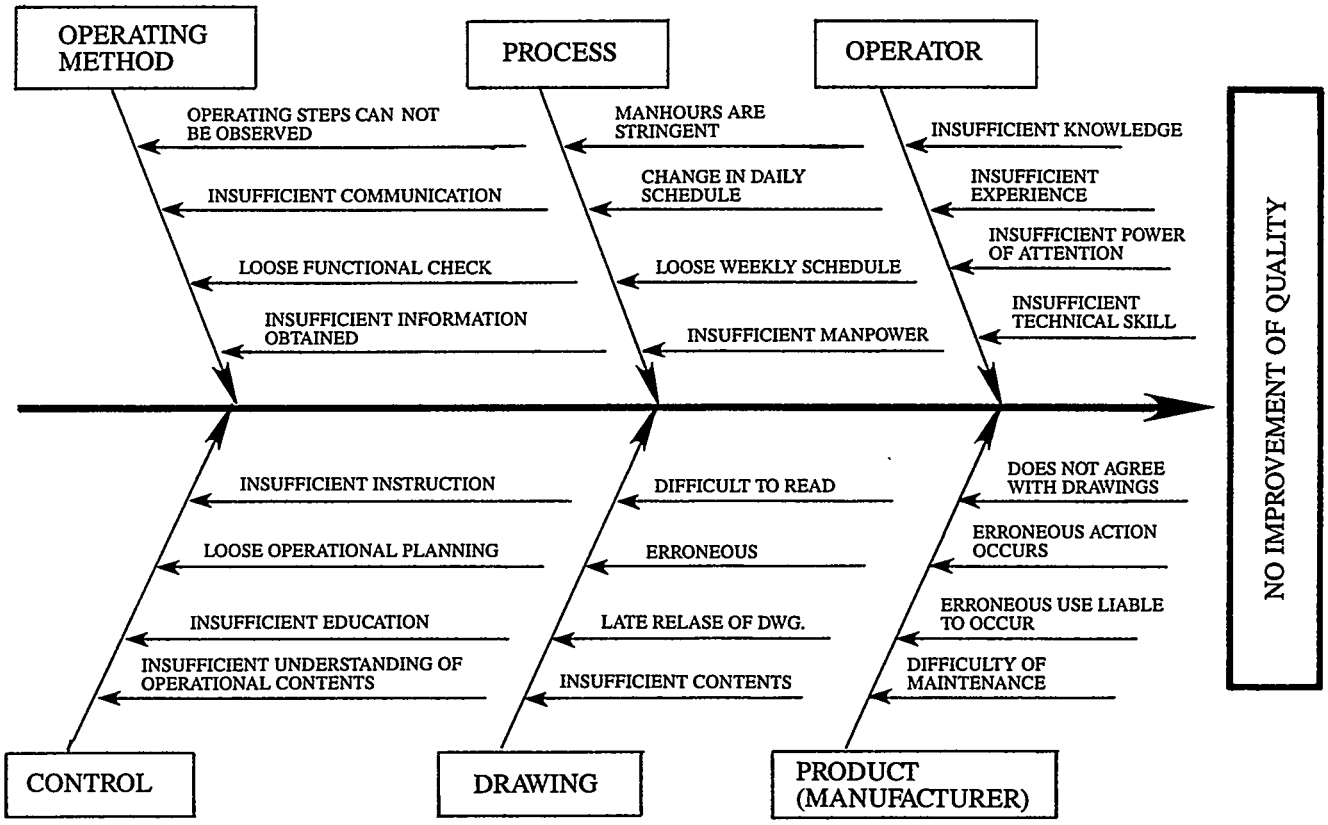
HISTORICAL MAN-HOURS	980H
TARGET MAN-HOURS	880H
MAN-HOURS IN PRACTICE	790H

10% UNDER TARGET

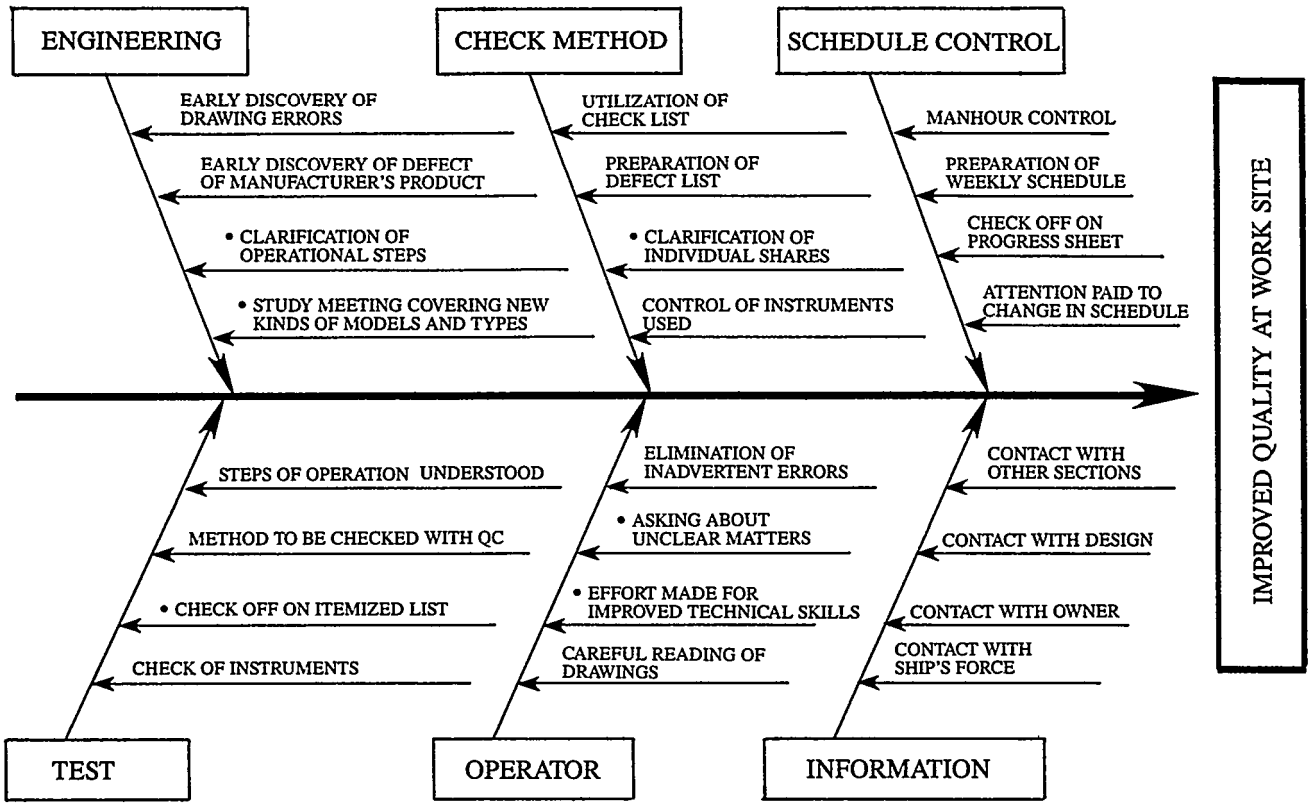
4. NUMBER OF SUGGESTIONS

2 SUGGESTIONS/MONTH/PERSON

FISHBONE DIAGRAM — ILLUSTRATING CAUSES OF A NEGATIVE EFFECT



FISHBONE DIAGRAM — ILLUSTRATING CAUSES OF A POSITIVE EFFECT



UNDERSTANDING PRESENT STATE

IN THE GROUP —

FEEDBACK IS PRACTICED

CHECK OFF ON SYSTEM DIAGRAM IS NOT PRACTICED

DEFECT DATA NOT OBTAINED

ANALYSIS OF DEFECT RATE OF,

OWN GROUP AND OTHER GROUPS } WILL BE IMPOSSIBLE.

DATA COLLECTION (THE 'KISO MARU')

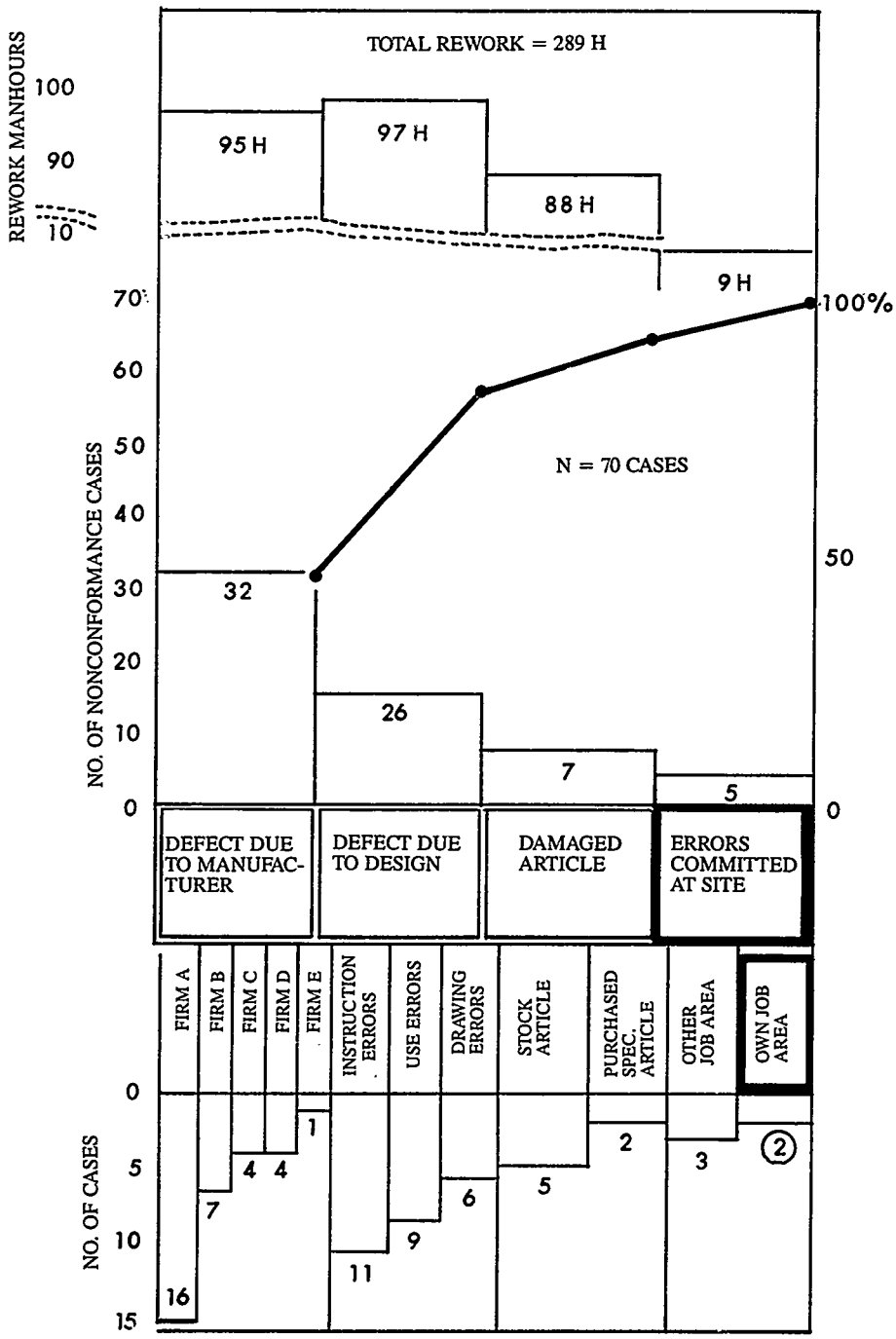
DEFECT LIST

NO.	CONTENTS	IN CHARGE	MAN-HOURS
1	GROUP ALARM WILL NOT FLICKER (FAULTY ANN.)	APPRO-PRIATED ARTICLE	MAKER
2	MANNER OF M/E SLOW-DOWN SIGNAL RECEIVED IS IRREGULAR.	DESIGN	2 H
3	BALLAST PUMP CANNOT BE STARTED REMOTELY.	OWN JOB AREA	1 H
4			
5			
70			20 H

CHECK SHEET

DEFECT DUE TO MANUFACTURER	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 //	32 CASES	45.7%
DEFECT DUE TO DESIGN	𝍸 𝍸 𝍸 𝍸 𝍸 /	26 CASES	37.2%
DAMAGED ARTICLE	𝍸 //	7 CASES	10%
ERROR COMMITTED AT SITE	𝍸	5 CASES	7.1%
	TOTAL	70 CASES	100%

ANALYSIS


TOTAL REWORK = 289 H
REWORK MANHOURS
100
90
10
95 H
97 H
88 H
9 H
70
60
50
40
30
20
10
0
100%
50
0
N = 70 CASES
NO. OF NONCONFORMANCE CASES
32
26
7
5
DEFECT DUE TO MANUFAC-TURER
DEFECT DUE TO DESIGN
DAMAGED ARTICLE
ERRORS COMMITTED AT SITE
FIRM A
FIRM B
FIRM C
FIRM D
FIRM E
INSTRUCTION ERRORS
USE ERRORS
DRAWING ERRORS
STOCK ARTICLE
PURCHASED SPEC. ARTICLE
OTHER JOB AREA
OWN JOB AREA
NO. OF CASES
0
5
10
15
16
7
4
4
1
11
9
6
5
2
3
2

RESULTS RELATIVE TO TARGETS WERE (SORRY TO MENTION)

1. EXTENSION ALARM (20 H)
2. AUTO SLOW DOWN (18 H)
3. BLACK OUT TEST (30 H)

REASONS: 1 AND 3 WERE DUE TO STOCK ARTICLES.

2 WAS DUE TO MANY REVISIONS MADE AFTER INSPECTION IN SHIPYARD._.

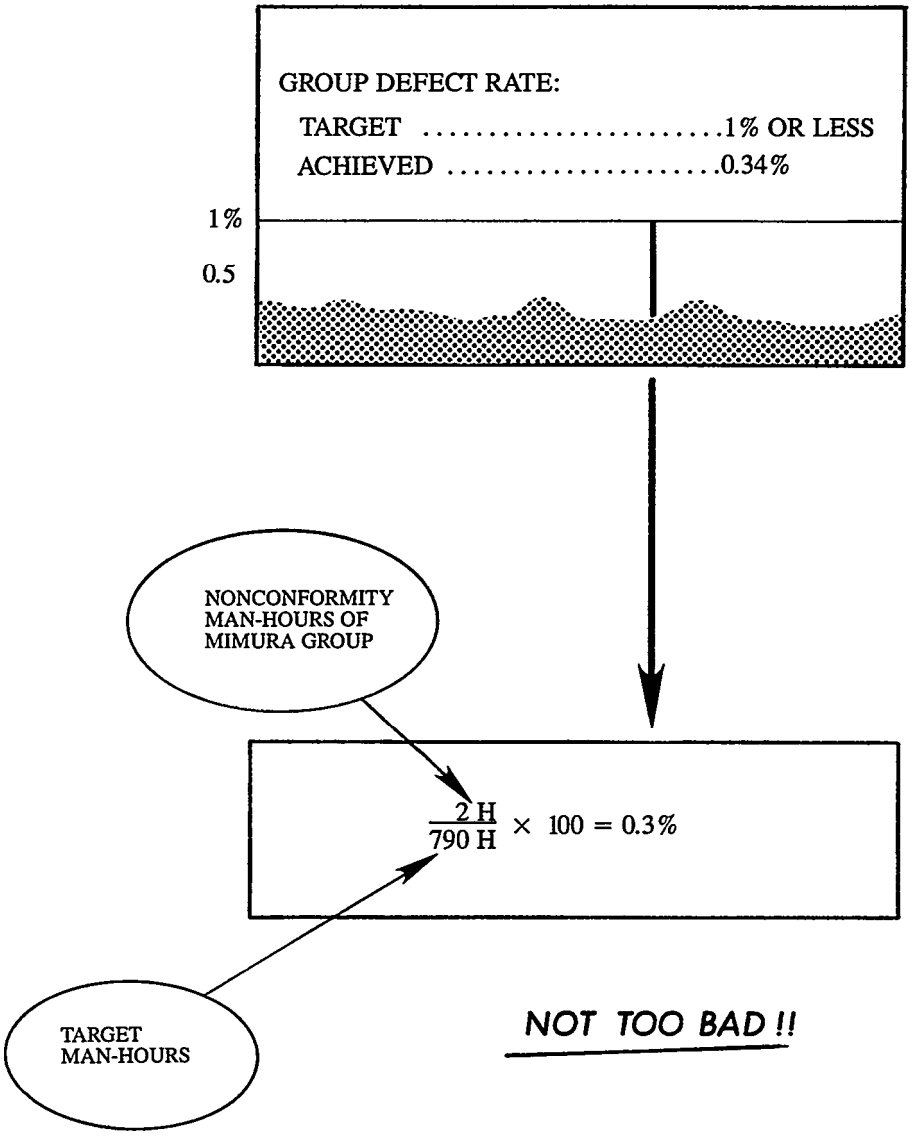
REJECTION RATE WITH ALARM CHECKS AS BASIS:

$$\frac{3 \text{ CHECKS}}{324 \text{ CHECKS}} \times 100 = 0.9\%$$

REJECTION RATE WITH MAN-HOURS USED AS BASIS:

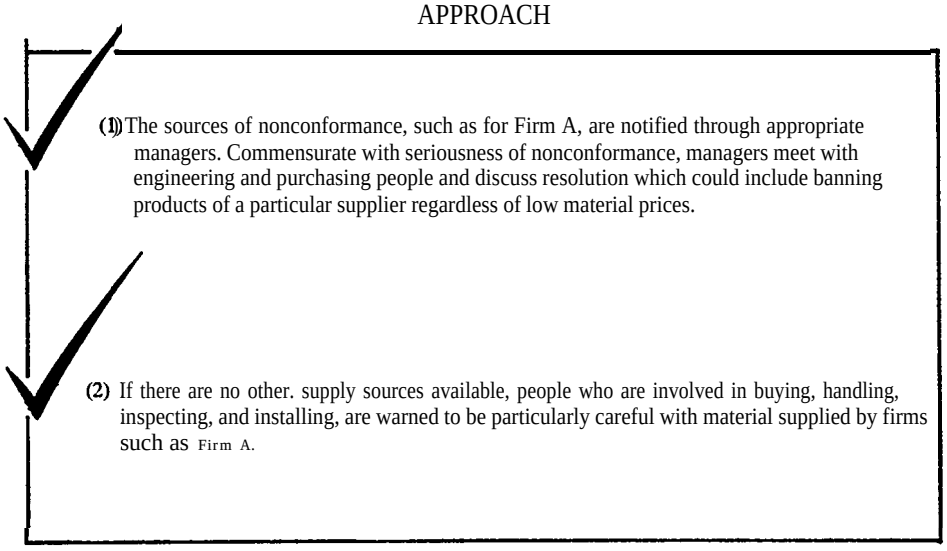
$$\frac{68 \text{ H}}{790 \text{ H}} \times 100 = 9\%$$

RESULTS OF THE GROUP DEFECT RATE WILL BE



COUNTERMEASURES FOR THE FUTURE

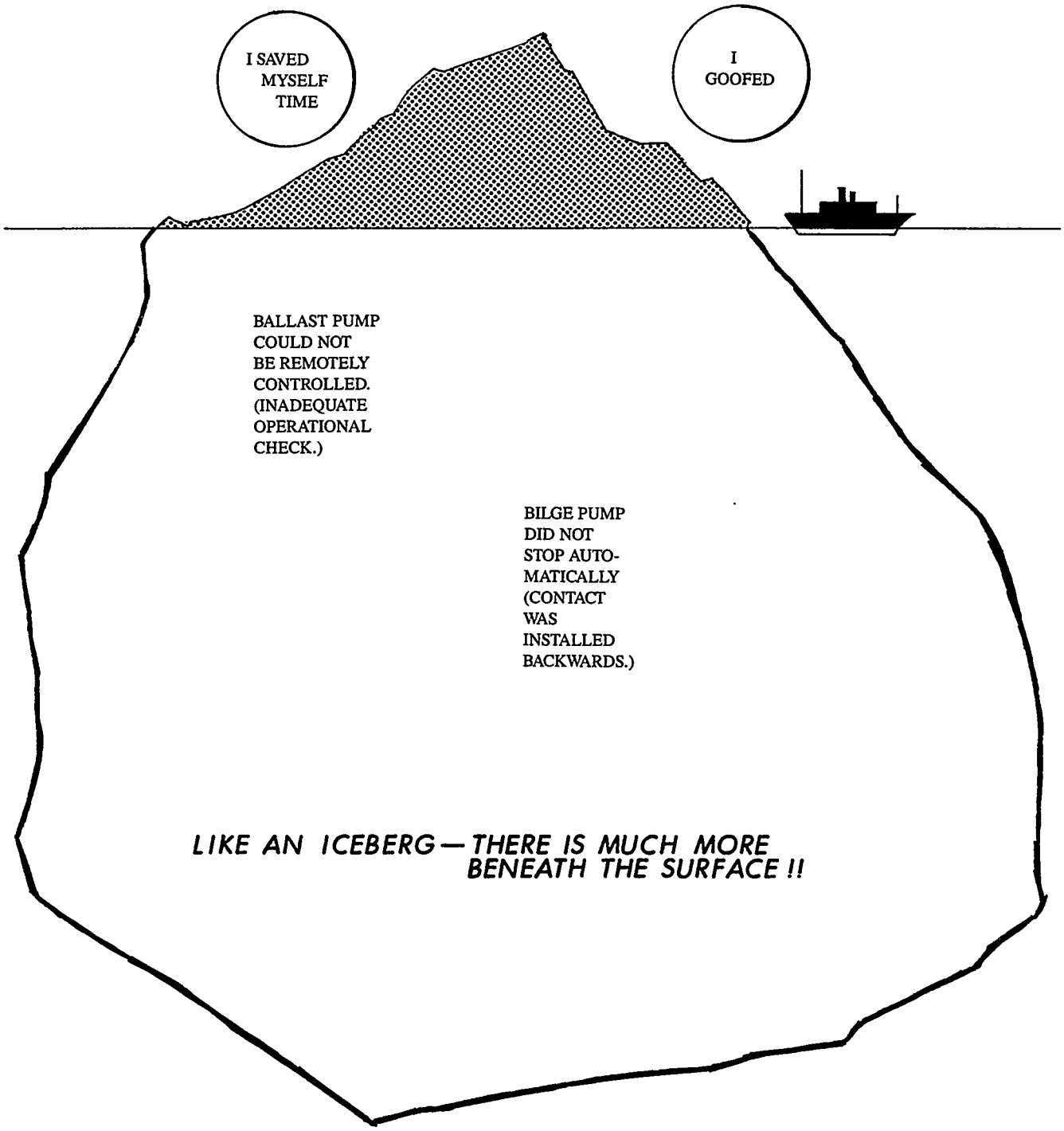
APPROACH



(1) The sources of nonconformance, such as for Firm A, are notified through appropriate managers. Commensurate with seriousness of nonconformance, managers meet with engineering and purchasing people and discuss resolution which could include banning products of a particular supplier regardless of low material prices.

(2) If there are no other. supply sources available, people who are involved in buying, handling, inspecting, and installing, are warned to be particularly careful with material supplied by firms such as Firm A.

CAUSES ATTRIBUTABLE TO SITE WORK (OWN GROUP)



COUNTERMEASURES AT SITE

OPERATE MACHINERY IN CONFORMANCE WITH INSTALLATION MANUALS AND THE TEST PLAN.

- STRENGTHENING CHECKS OF DRAWING AND MATERIALS.
- EARLY DISCOVERY AND HANDLING OF PROBLEMS.

LEAD SUPPLIERS' COMPANIES REGARDING REQUIRED TECHNICAL SKILLS.

- STUDY MEETINGS.
- OPERATIONAL IMPROVEMENT AND ELIMINATION OF WASTE.

DO NOT REPEAT SAME MISTAKE

- OPERATIONAL STANDARD WILL BE OBSERVED TO AVOID INADVERTENT ERRORS
- CASE STUDIES WILL BE UTILIZED AND FED BACK

ELECTRICAL OUTFITTING

FROM NOW ON, **MORE LIVELY TQC ACTIVITIES CENTERING AROUND GROUP MEETINGS WILL BE DEVELOPED AND ALL OUT EFFORTS WILL BE MADE FOR OUT AND OUT SUCCESS IN ELECTRICAL OUTFITTING,**

APPENDIX D

Examples of the Activities of Analytical Quality Circles

in IHI Shipyards

Case	Target
1	Improve Efficiency of Plate-Joining Process
2	Improve Efficiency for Assembling Tank Blocks
3	Reduce Block Assembly Costs
4	Reduce X-Ray Inspection Defect Rate for Plate Joining
5	During Erection of LPG SNO. 2922 Reduce X-Ray Inspection Defect Rate
6	Obtain Improved X-Ray Inspection Results for Erection Welding
7	Save Thermal Energy
8	Improve Distortion Removal Efficiency
9	Reduce On-Board Welding Man-Hours (Machinery Fitting Section)
10	Reduce Lost Work and Time on the Medium- and Large-Bore Pipe Piece Fabrication Line
11	Challenge Welding Efficiency (Hull Fabrication Shop)
12	Reduce Temporary Fitting Pieces (dogs, clips, etc.)
13	Improve Efficiency for Fitting Make-Up Pipe Pieces
14	Improve Observance of Compartment Hot-Work Scheduled Completion Dates (Deck Fitting Section)
15	Perform Deck Covering Work Within Budgeted Man-Hours
16	Reduce Budgeted Man-Hours (Accommodation Fitting Section)
17	Reduce Budgeted Man-Hours (Painting Section)
18	Improve Conformance With Drawing Issue Dates
19	Reduce the Number of Elbows in Pipe Systems
20	Cut Back Design Man-Hours

Target: Improve Efficiency of Plate-Joining Process

1. Summary

In our Group. subassemblies are made from parts previously cut by the Hull Fabrication Shop from plates and shapes. We are engaged in five kinds of operations: plate-alignment and tack welding, one-side-automatic welding (FCB Union), piece installation and finishing, marking, and gas cutting.

2. Selection of Target

All Group members met and decided to select a theme along the lines of the Section's target (Reduce the Section's Budget by XX%) and to review our operations for the five kinds of work. As a result, it was determined that a problem exists because time is dispersed between the different work processes so as to prevent uniform work flow.

3. Current Status Analysis

Study of past work disclosed that for 2-seam (3-plate) panels tack welding consumed an average of 3.5 man-hours (H), FCB Union welding 3.4 H, finishing 3.3 H, marking 2.3 H, and gas cutting 2.0 H. Thus, for each panel, the total man-hours consumed was 14.5 H and as each seam length was 16 meters (M), efficiency was rated as (16 M x 2)/14.5 H = 2.2M/H.

4. Target Setting

Tack welding and FCB Union welding, which could be expressed in meters, were considered as the main work flow and 2.0 H was allocated for each work process. On this basis efficiency would be 32 M/(2.0 H x 5) = 3.2 M/H. A decision was made that as a starter, something less, i.e., an efficiency of 2.8 M/H (up 27%) would be our target. In other words, uniform flow was an ideal objective, but for the time being something less was practical.

5. Problems Identified and Countermeasures

The Group brainstormed and identified problems using a Fishbone Diagram. Decisions were made about which problems were to be assigned to Group members and which were to be sent to management as suggestions for improvement. Improvements made included: a card method for a seam control system, a date control method, and a block setting jig.

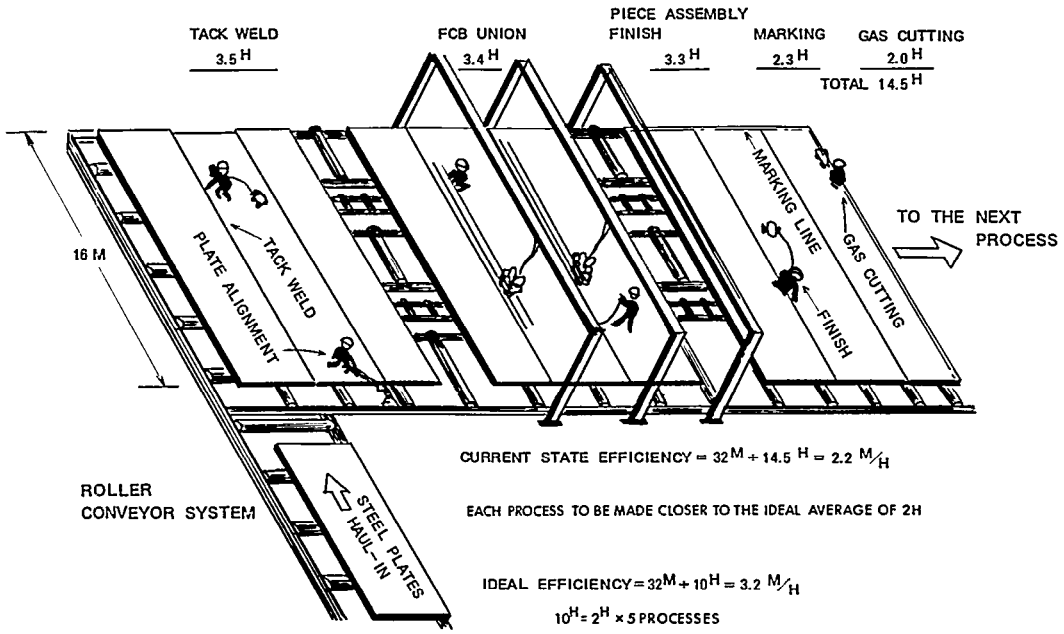
6. Effects

Because of the countermeasures, an efficiency of 2.6 M/H was obtained on the seventh vessel (up 17%).

7. Future Problems

Problems to be handled next include: reduce waiting time for carriages and cranes, and special attention to low efficiency blocks.

TARGET SETTING



CURRENT STATE EFFICIENCY = $32^{M} + 14.5^{H} = 2.2\ ^{M}/_{H}$

EACH PROCESS TO BE MADE CLOSER TO THE IDEAL AVERAGE OF 2H

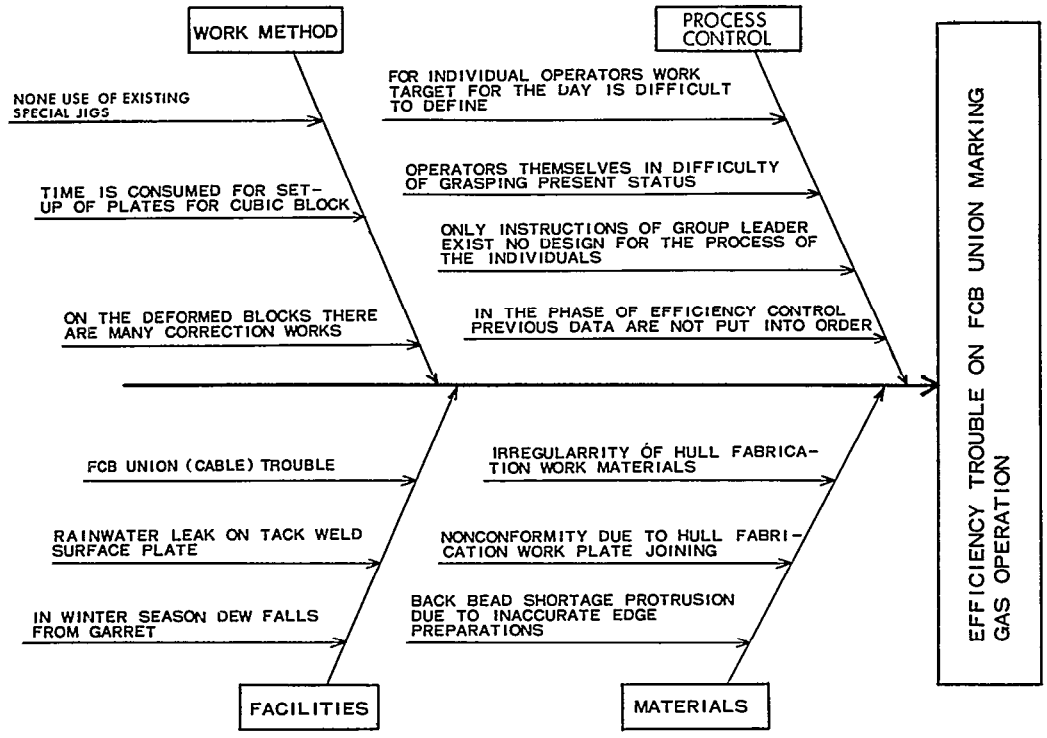
IDEAL EFFICIENCY = $32^{M} + 10^{H} = 3.2\ ^{M}/_{H}$

$10^{H} = 2^{H} \times 5$ PROCESSES

TARGET: ON S. NO. 2893 EFFICIENCY TO BE 2.8 $^{M}/_{H}$ OR BETTER.

M = METER
H = MAN-HOUR

CHARACTERISTICS DIAGRAM (FISHBONE)



POINTS AT ISSUE AND COUNTERMEASURES

DIVISION	No.	POINTS AT ISSUE	COUNTERMEASURES	REMARKS
PROCESS CONTROL	1	FOR THE OPERATR HIMSELF IT WILL BE DIFFICULT TO GRASP PRESENT STATUS.	SEAM CONTROL SYSTEM CARD HAS BEEN PREPARED.	
	2	ONLY INSTRUCTIONS OF THE GROUP LEADER EXIST. NO DESIGN FOR THE PROCESS OF THE INDIVIDUALS.	UTILIZATION OF DATA ANALYSIS METHOD.	
	3	IN THE PHASE OF EFFICIENCY CONTROL PREVIOUS DATA ARE NOT PUT INTO ORDER.	〃 〃	
WORK METHOD	4	ON THE DEFORMED BLOCKS THERE ARE MANY CORRECTION WORKS REQUIRED.	IMPROVEMENT WILL BE MADE ACCORDING TO SUGGESTIONS.	
	5	TIME IS COSUMED FOR SET-UP PF PLATES FOR CUBIC BLOCKS.	JIG IS DEVELOPED FOR FITTING OF THE BILGE SHELL PLATING TO KEEL.	
	6	STANDBY OF FCB UNION DUE TO WAITING FOR TACK WELD.	CHANGE MADE FOR PERSONNEL ASSIGNMENT GIVING PRIORITY TO TACK WELD.	
MATERIALS	7	OCCURRECNE OF LABOR IDLING DUE TO IRREGULARITY OF PLATING.	IMPROVEMENT THROUGH SUGGESTIONS AND FEEDBACK.	
	8	BACK BEAD SHORTAGE IN PROTRUSION DUE TO INACCURATE EDGE PREPARATIONS.	〃 〃	
	9	FCB UNION ABSENCE DUE TO DISTORSION OF HULL FABRICATION PLATE JOINING.	CORECTION THROUGH BACK STRETCH AND OTHER REINFORCEMENTS.	
FACILITIES	10	FCB UNION TROUBLE (CABLE).	REINFORCEMENT OF CABLE.	
	11	RAINWATER LEAK, CEILING DEW DROP.	IMPROVEMENT THROUGH SUGGESTION AND REQUEST PRESENTED TO THE SUPERIORS.	

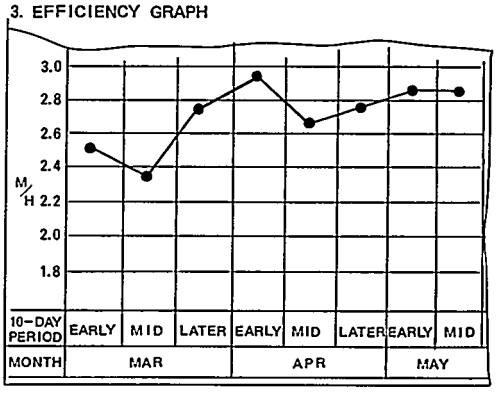
EXAMPLES OF IMPROVEMENT

DATA CONTROL SYSTEM

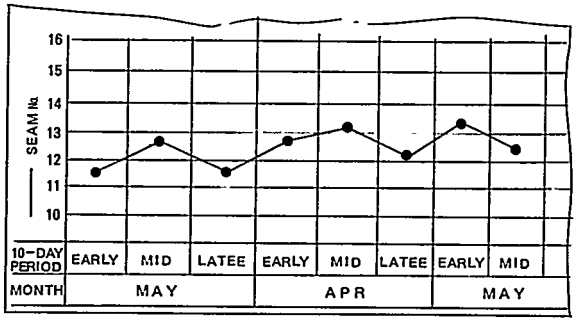
1. EFFICIENCY MANHOUR SHEET ACCORDING TO BLOCKS

MO/DAY	BLOCK NAME	UNION (M)	SEAM No. (PCS)	TACK WELD (H)	UNION (H)	CORRECTION (H)	MARKING (H)	GAS CUTTING (H)	TOTAL (H)	EFFICIENCY (M/H)	REMARK
3/2	SP5P	32	2	4	4	4	2	2	16	2.00	
	SP5S	32	2	4	4	4	3	2	17	1.88	
	LT6P	32	2	3	3	3	3	2	14	2.28	
	〃 S	32	2	3	4	3	3	2	15	2.13	
3/3	L11P	48	4	6	6	4	4	3	23	2.09	
	〃 S	48	4	6	6	4	3	3	22	2.18	
	LT7P	32	2	3	3	3	3	2	14	2.28	
	〃 S	32	2	3	3	3	3	3	15	2.13	

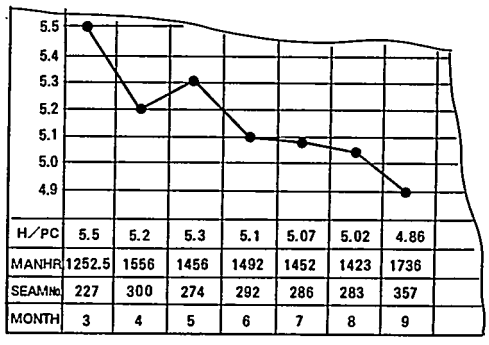
3. EFFICIENCY GRAPH



2. FCB SEAM/ONE DAY GRAPH



4. MANHOUR/FCB SEAM GRAPH



H/PC	5.5	5.2	5.3	5.1	5.07	5.02	4.86
MANHR	1252.5	1556	1456	1492	1452	1423	1736
SEAM No.	227	300	274	292	286	283	357
MONTH	3	4	5	6	7	8	9

Target: Improve Efficiency for Assembling Tank Blocks

1. Process Summary

The processes performed by our Group range from marshaling required parts and subassemblies to final assembly of blocks.

2. Selecting and Setting a Target

As a **consequence** of the **Section target (Reduce** Costs), our Group held a conference and decided to address all blocks, but as a Pareto analysis clearly showed that bottom blocks account for 60% of our work we emphasized bottom-block production accordingly. The target was set to achieve a 10% increase in efficiency for SNO. 2922 as compared to producing tank blocks for the ship previously constructed.

3. Identifying Problems

The Group employed a Fishbone Diagram to identify problems.

4. Establishing Countermeasures and Executing

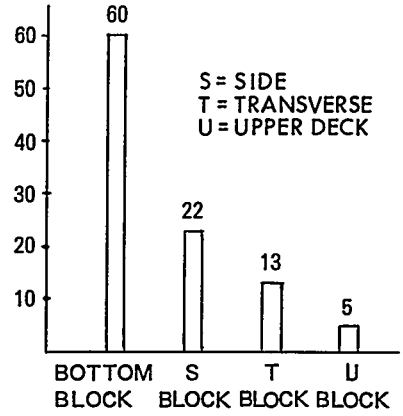
Countermeasure plans were organized, e.g., review operational steps, suggestions for improvement, improve processes, and requests for cooperation from other groups (improved feedback).

5. Effects

Special jigs and a methods manual were prepared resulting in accelerated work without people working harder. Also, the volume of suggestions submitted by Group members increased to 2.025 suggestions/month/person over a six month period. In addition, because of better feedback to the Hull Fabrication Shop, our rework of parts during the framing stage reduced from 55% to 42%, and during the block assembly stage from 65% to 51%. As a result, we increased our efficiency by 11% so as to exceed our target by 1%.

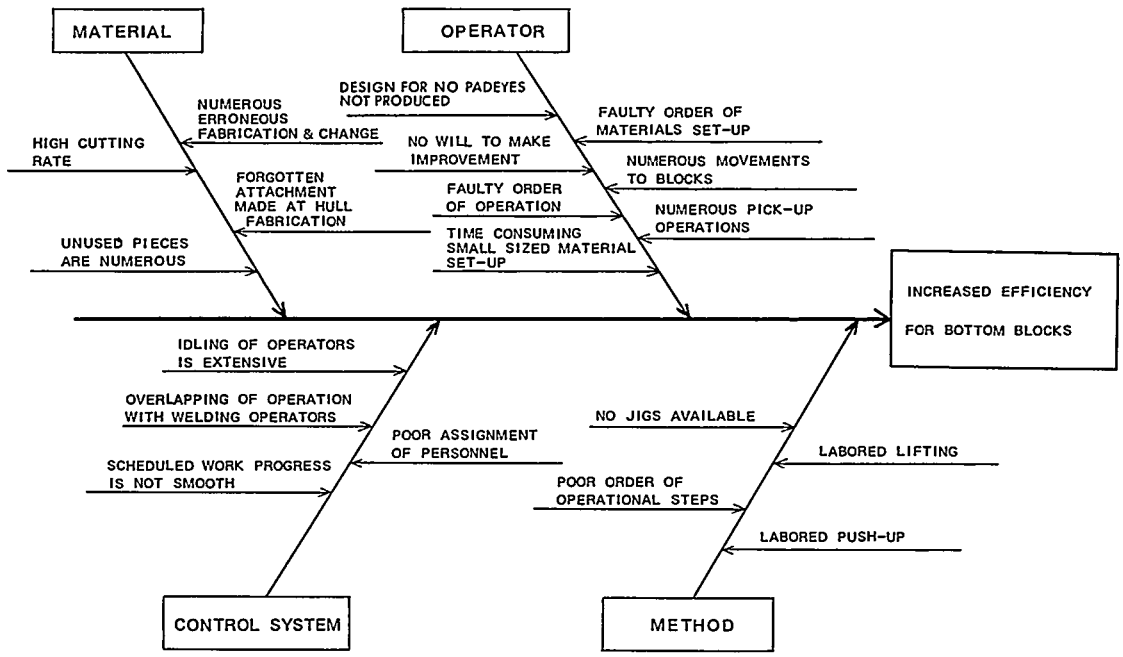
6. Future Themes

In the future we plan to monitor the accuracy of parts and provide improved feedback to the Hull Fabrication Shop. Also, we will continue to meet to study all stages of operations from material marshaling through final block assembly in an attempt to further increase efficiency.



CHARACTERISTICS DIAGRAM

(FISHBONE CHART)



POINTS OF ISSUE FOR BOTTOM BLOCKS & COUNTERMEASURES

POINTS OF ISSUE	COUNTERMEASURES
1. TACK WELDING ORDER DIFFERS ACCORDING TO DIFFERENT OPERATORS. 2. STEPS OF MATERIALS SET-UP ARE NOT DEFINITE. 3. IDLING OF OPERATORS IS EXTENSIVE.	→ 1 MANUALS FOR OPERATIONAL STEPS AND METHOD TO BE PREPARED AND ADEQUATE USE OF PERSONNEL TO BE DESIGNED.
4. EXPERIENCED DIFFICULTY IN PERFORMING PUSH-UP. 5. EXPERIENCED DIFFICULTY IN PERFORMING DRAW-TOGETHER. 6. NO JIGS & TOOLS AVAILABLE. 7. NUMEROUS CORRECTIONS ON THE PART OF WELDING OPERATORS. (AFTER RELEASE OF PIECES) 8. DESIGNS FOR IMPROVMENET TO ACHIEVE NO-PIECE OPERATION HARDLY SUGGESTED.	→ 2 NO PADEYE PROCESS OF OPERATION TO BE DESIGNED
9. WILL TO MAKING IMPROVEMENT ON THE PART OF GROUP MEMBERS NOT AROUSED.	→ 3 INVIGORATION OF IMPROVEMENT SUGGESTIONS.
10. WAY NUMEROUS CUTTINGS.	→ 4 CUTTING DATA TO BE COLLECTED AND FEEDBACK GIVEN TO HULL FABRICATION.
11. TIME CONSUMING MATERIALS SET-UP FOR SMALL-SIZED ARTICLES. (AVERAGE 120 PCS FOR A BLOCK)	→ 5 RATIONALIZED SET-UP PF SMALL-SIZED ARTICLES.
12. NUMEROUS PICK-UP OPERATIONS. (FORGOTTEN ATTACHMENT OF SMALL-SIZED ARTICLES: ERRONEOUS ATTACHMENT, ETC.)	→ 6 PREVENTION OF MISS-ATTACHMENT BY DOUBLE CHECK.

COUNTERMEASURE 1

ADEQUATE ASSIGNMENT OF PERSONNEL

MANUALS FOR OPERATIONAL STEPS AND OPERATIONAL METHOD

STEPS / ITEMS	1	2	3	4	5	6	7	8	9	10	11
OPERATIONAL STEPS	PLATE MARKING CUTTING	GUNWALE ERECTION	LOOSE SET-UP	FRAME INSERTION	EDGE RETAINING	MAGNET TACK WELD	SMALL-SIZED ARTICLE SET-UP	OVERALL TACK WELD	GUNWALE ERECTION	END PLATE ERECTION	SHIPWRIGHT
ADEQUATE PERSONNEL	2	2	2	1	3	2	1	3	2	1	1
OPERATIONAL METHOD	NAMES OF SMALL ARTICLES ENTERED	WOODEN PATTERN MATCHING PUMP WELL PLATE JOINING ADVANCED WELDING	SMALL ARTICLES TACK WELDING	PUT TO THE STATE OF BEING PULLED	THE F TO BE CUT	TACK WELD FROM END 3T LEVER USED POWER CHARGE	DIVIDED FLOOR BY FLOOR	TACK WELD FLOOR BY FLOOR	LEVEL CHECK	CUT SURFACE GROUND	MISALIGNMENT BETWEEN AGGREGATE ELIMINATED
SPECIALIZED JIGS	MARKING TAPE SPACE WIDIN TAPE	R PATTERN	POWER PUSH JIG	SOCKET JIG SPACE SHIFT JIG BACKING MARK	PULLING JIG	3T LEVER		SQUARE MATERIAL PULL JIG	LEVEL JIG STRING JIG	PLATE RESTPIECE JIG PUSH JIG	REST JIG

- AS INDICATED IN THE ABOVE TABLE, DIVISION HAS BEEN MADE FOR OPERATIONAL STEPS, ADEQUATE PERSONNEL. SPECIFIC JIGS AND A MANUAL WERE PREPARED IN ORDER TO CLARIFY JIGS SET-UP ETC., USED FOR OPERATIONS BY INDIVIDUAL OPERATORS. AS A RESULT THE JOB OF EVERY MEMBER HAS BEEN ACCELERATED AND THE JOB HAS BEEN PERFORMED WITH ESSENTIAL POINTS TACKLED.

POINTS AT ISSUE & THEMES OF THE FUTURE

No.	POINTS AT ISSUE	COUNTERMEASURES OF THE FUTURE
1	EXCESSIVE HOURS COSUMED IN FABRICATION OF STEPPED SURFACE PLATE (FABRICATION HRS = ABT. 800 HRS)	CHALLENGE FOR SURFACE PLATELESS PROCESS DESIRED.
2	MANY FLAWS EXIST ON THE BLOCK YET. (200 LOCATIONS IN A BLOCK)	IMPROVEMENT OF JIGS AND TOOLS TO BE PUSHED FURTHER.
3	CUTTING OF SMALL-SIZED MEMBERS EXTENSIVE YET. (PRESENT RATE OF CUTTING: 51%)	ONE ARTICLE ONE ACCURACY TO BE ASSURED: DATA TO BE COLLECTED FOR FEEDBACK. (RATE OF CUTTING TO BE REDUCED TO 20% OR LESS)

ITEMS TO BE REQUESTED OF OTHER SECT. AND DEPT.

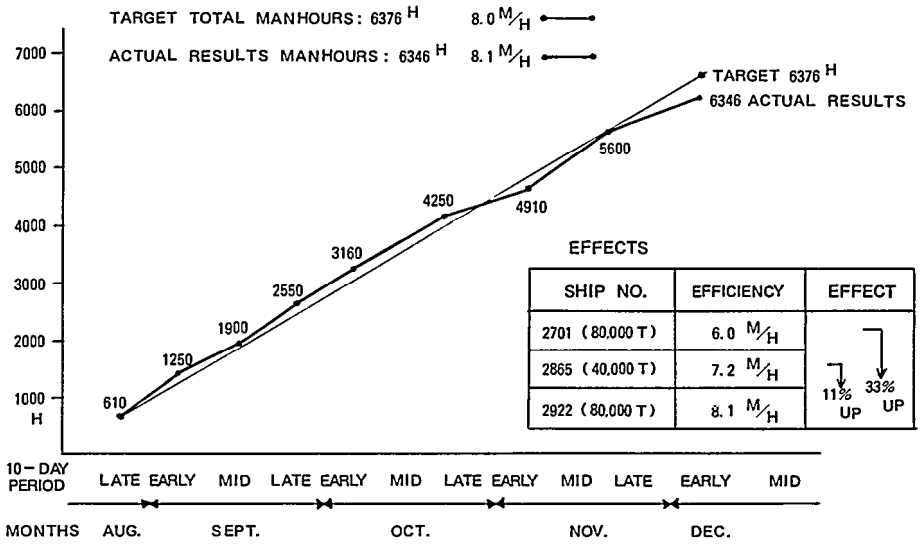
WASTEFUL WORKS LIKE CHANGES AND MISSFABRICATION ARE NUMEROUS. (105 CASES ON 55 BLOCKS)	PRECEDING PROCESSES (DESIGN; MOLD LOFTS) TO BE REQUESTED FOR RADICAL ELIMINATION. OF WASTEFUL WORKS.

GROUP POLICY OF ACTIVITIES FOR THE FUTURE

1	TOP POSITION OF SUGGESTION ACTIVITIES TO BE MAINTAINED.	THREE SUGGESTIONS OR OVER PER MEMBER PER MONTH TO BE MAINTAINED: IMPROVEMENT RATE OF 90% OR OVER TO BE AIMED AT.
2	A FEW PERSONS HAVE THE CAPACITY OF BEING ENGAGED IN ALL OPERATIONS OF MATERIALS SET-UP, FRAMING AND ASSEMBLY.	PERIODICAL STUDY MEETING AND REFLECTION MEETING TO BE HELD FOSTERING TO BE CARRIED OUT IN-PROCESS OF ACTUAL JOBS UNDER ROTATION SYSTEM ORGANIZED.

EFFECTS

TARGET, ACTUAL RESULTS MANHOUR TABLE



EFFECTS

SHIP NO.	EFFICIENCY	EFFECT
2701 (80,000 T)	6.0 M/H	11% UP, 33% UP
2865 (40,000 T)	7.2 M/H	
2922 (80,000 T)	8.1 M/H	

Target: Reduce Block Assembly Costs

1. Summary of Process

Our Group consists of eight fitters and eight welders and all understand that block assembly is very closely linked to hull erection. Thus any attempt to reduce costs has to consider the costs of erection processes.

2. Setting a Target Value

In the past fitters and welders were separately organized. Each was concerned with their own processes to the exclusion of the other's. Now that cost per product is paramount, our Group is organized with both fitters and welders as a single team. Also, because of the potential to impact on erection costs, we usually participate as members of a joint group. Joint scheduling and methods of operation are necessary for improvement. It was a joint group which decided to challenge block assembly costs in order to achieve a reduction of 10% as compared to man-hours expended for the previous vessel.

3. Problems Identified, Planning, and Execution

Group members developed a Fishbone Diagram to identify problems and their relationships. Particular attention was given to the method of operation for block assembly. Discussions centered on balanced operations, timing, adequate numbers of workers, etc. It was decided to assign responsiblity for studying operations for assembly work by block types, i.e, an individual would be concerned with operations concerning one block type. The decision also addressed need to review and change such operations from time to time. Another decision made was to increase the rate of usage of C02 semiautomatic welding. And, to ensure that defects are recorded and fed back properly, a person responsible for data recording was assigned.

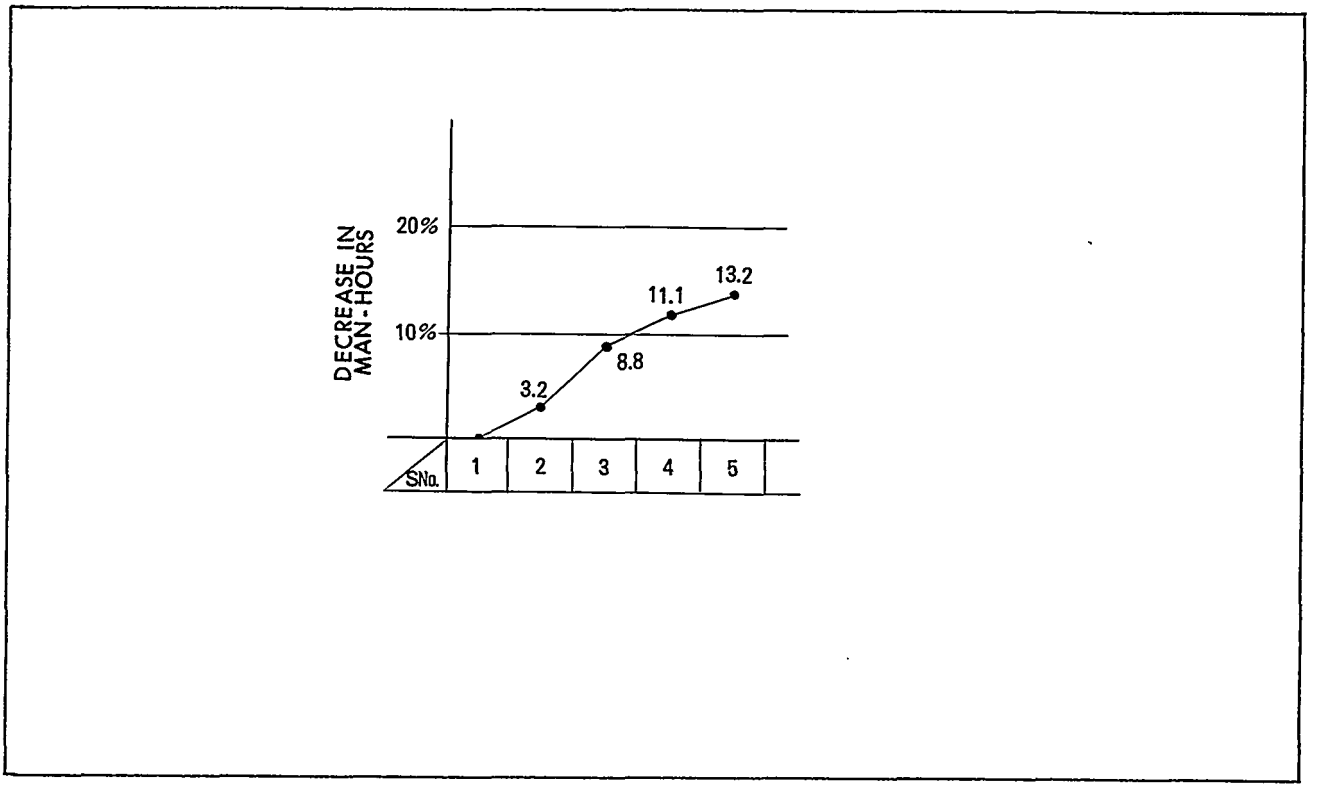
4. Effects and Countermeasures

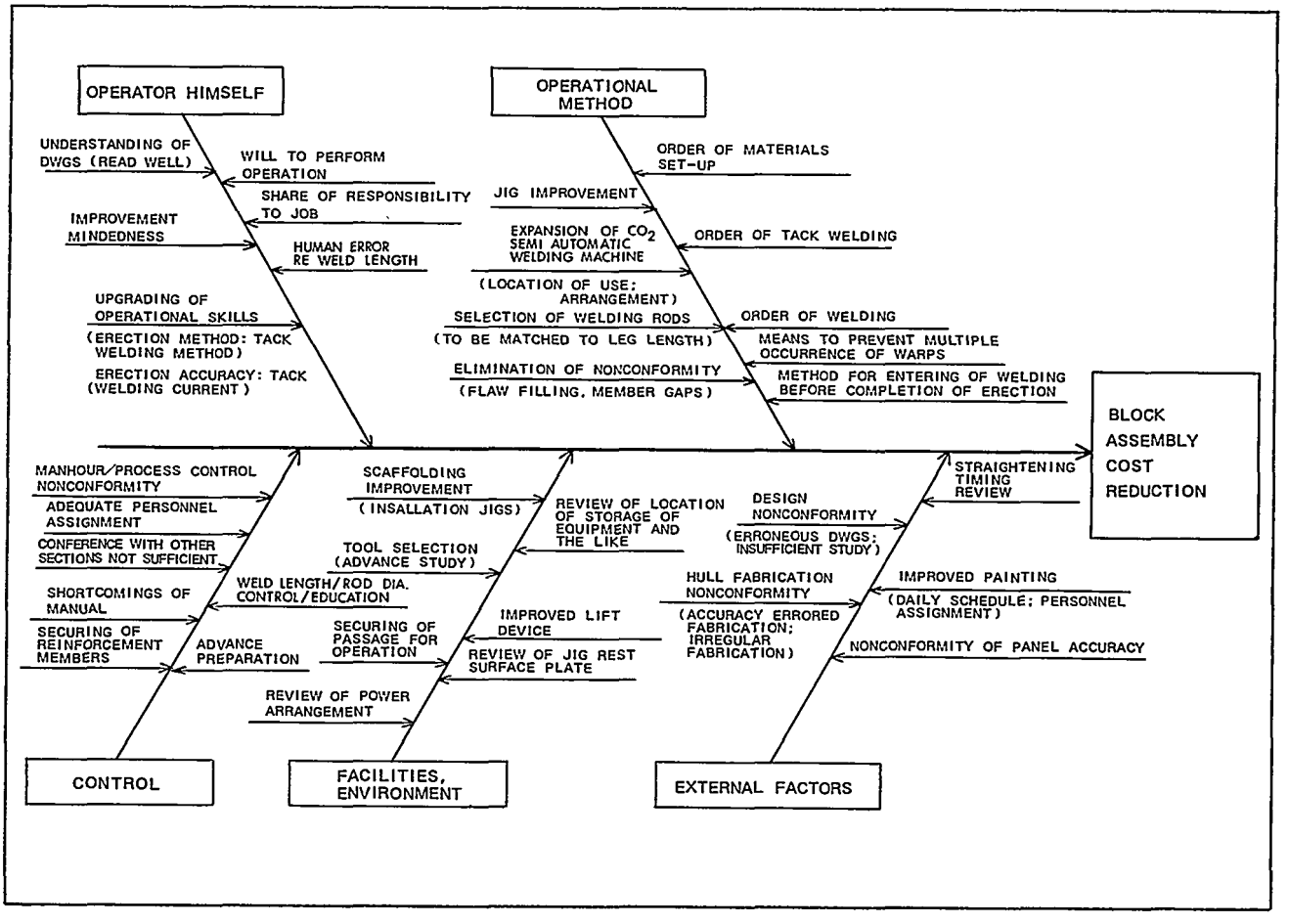
Depending on block types it is possible to fix processes in order to achieve a good balance of erection fitters and welders. This also involved discussions with design people. Development of methods for easier operations have particularly centered on erection welders. Design details were modified to make more use of the C02 automatic welding machines which make it possible to accurately record the usage of welding wire per day per operator. Each operator suddenly developed quite an awareness of efficiency. For SNO. “5”, the rate of usage of C02 automatic welders reached 60% of all welds. With individuals assigned by block types, man-hour data was recorded block by block and anything out of normal became quickly obvious so that remedial measures could be applied quickly. As indicated on the accompanying,,graph, for SNO. “4” man-hours were reduced by 11.1% as compared with SNO. "1".

5. Future Theme

Group activities as described in the foregoing will be continued and challenging targets will continue to be applied.

Subassembly and Assembly Section





AN EXAMPLE OF DATA RECORD KEEPING TABLE

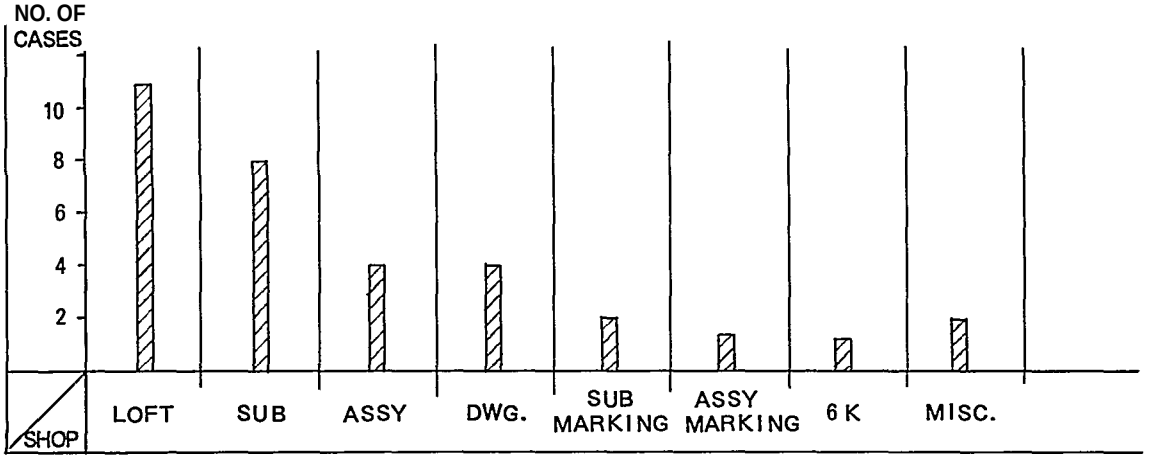
DATA RECORD ITEMS		PERSON IN CHARGE
A)	PORTION OF CORRECTION DUE TO FAULTY ACCURACY	A
B)	PORTION OF CORRECTION DUE TO MISSFABLICATION	B
C)	WELD LENGTH MADE BY CO_2 SEMI AUTOMATIC WELDING MACHINE	C
D)	ACCUMULATION FO ASSEMBLY HOURS; PROCESS NONCONFORMITY ES	D
E)	LENGTH OF WELD CORRECTION PORTIONS; LOCATIONS OF WELD LEG LENGTH NONCONFORMITY	E
F)	NUMBER OF REINFORCEMENT MEMBERS INSTALLED	F
G)	LOCATIONS OF SCAFFOLDING NONCONFORMITIES	G
P		

AN EXAMPLE OF PROCESS CONTROL

GSU 52

COMPARTMENT NAMES	SCHEDULED MANHOURS	ACTUAL MANHOURS
F D 52	70 H	55 H
U 52	30 H	34 H
GSU 52	250 H	238 H
LINE HEATING	60 H	47 H
GRINDING	40 H	35 H
TOTAL	450 H	409 H

AN EXAMPLE OF NONCONFORMITY OCCURRENCE SECTORS (DURING TWO MONTHS)



Target: Reduce X-Ray Inspection Defect Rate for Plate Joining

1. Process Summary

Our Group members are engaged in plate joining for panels.

2. Target Selection

The panels our Group produces are used mainly for blocks which comprise the cargo areas of tankers. We have decided to-focus on improving quality within our budgeted assembly man-hours. Thus, our target is to reduce the number of weld deficiencies disclosed by X-Ray inspection.

3. Setting the Target Value

Study of historical records disclosed that the number of X-Ray photographs showing deficiencies relative to all X-Ray exposures was 6.2% for manual welding and 3.0% for automatic welding. We decided to set our targets at 3.0% and 2.5% respectively.

4. Analysis, Countermeasures, and Execution

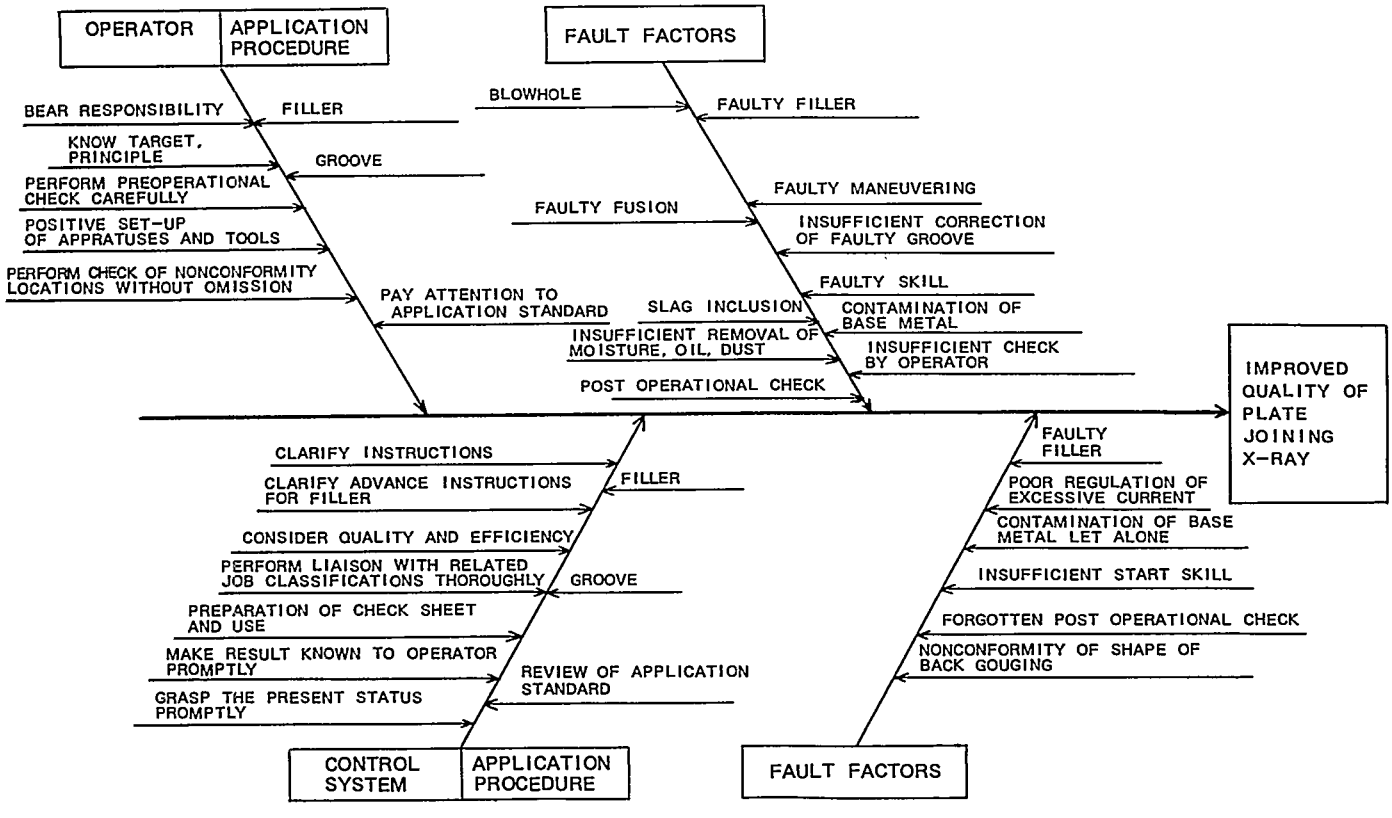
Studies were conducted, problems were identified, and problem relationships with each other were organized on a Fishbone Diagram. Discussion centered on problem causes and countermeasures. Note was particularly made of the data which showed increased porosity and slag inclusions. Thus, a decision was made to pay more attention to drying welding rods at 350-400 degrees Centigrade and afterwards to provide for storage of the rods in a thermostatically controlled enclosures at 50-70 degrees Centigrade. Also it was decided that where two-side welding was required, welding of the front side and the back side would be performed by the same operator to facilitate identifying causes of a defect and countermeasures. When X-Ray examinination discloses a fault, a discussion is to be held promptly between the operator responsible and the assistant foreman to identify the cause and apply a remedy. It was also decided that at each monthly meeting experiences will be exchanged concerning causes, countermeasures, and results.

5. Effects and Reflection

As a result of efforts applied steadily over a 5-month period, the X-Ray disclosed fault rate decreased to 3.26% (49 out of 1,505) for manual welding and to 2.56% (8 out of 313) for automatic welding. The new procedures identified poor performance for the following blocks:

3BC1	10.7% (3 out of 28)
3BS1	25.0% (6 out of 24)
4BS3	13.3% (12 out of **90)**

Conceivable causes for the latter pertain to preparations, such as weld gaps and tack welds. As insufficient operator skill is also conceivable, more education, training, and guidance is necessary. In particular, many defects created by automatic welders were in curved portions of plates. Thus, a special study of this problem was suggested to management. Group members are still striving to meet their original target.


OPERATOR
APPLICATION PROCEDURE
FAULT FACTORS
BEAR RESPONSIBILITY
FILLER
BLOWHOLE
FAULTY FILLER
KNOW TARGET, PRINCIPLE
GROOVE
PERFORM PREOPERATIONAL CHECK CAREFULLY
FAULTY MANEUVERING
FAULTY FUSION
INSUFFICIENT CORRECTION OF FAULTY GROOVE
POSITIVE SET-UP OF APPRATUSES AND TOOLS
FAULTY SKILL
PERFORM CHECK OF NONCONFORMITY LOCATIONS WITHOUT OMISSION
PAY ATTENTION TO APPLICATION STANDARD
SLAG INCLUSION
CONTAMINATION OF BASE METAL
INSUFFICIENT REMOVAL OF MOISTURE, OIL, DUST
INSUFFICIENT CHECK BY OPERATOR
POST OPERATIONAL CHECK
IMPROVED QUALITY OF PLATE JOINING X-RAY
CLARIFY INSTRUCTIONS
FAULTY FILLER
CLARIFY ADVANCE INSTRUCTIONS FOR FILLER
FILLER
POOR REGULATION OF EXCESSIVE CURRENT
CONSIDER QUALITY AND EFFICIENCY
CONTAMINATION OF BASE METAL LET ALONE
PERFORM LIAISON WITH RELATED JOB CLASSIFICATIONS THOROUGHLY
GROOVE
INSUFFICIENT START SKILL
PREPARATION OF CHECK SHEET AND USE
FORGOTTEN POST OPERATIONAL CHECK
MAKE RESULT KNOWN TO OPERATOR PROMPTLY
NONCONFORMITY OF SHAPE OF BACK GOUGING
REVIEW OF APPLICATION STANDARD
GRASP THE PRESENT STATUS PROMPTLY
CONTROL SYSTEM
APPLICATION PROCEDURE
FAULT FACTORS

Target: During Erection of LPG SNo. 2922 Reduce X-Ray Inspection Defect Rate

1. Process Summary

Our Group is in charge of accuracy control, but also performs X-Ray inspection of erection welding with special attention to major joints.

2. Setting a Target

In line with the shipyard target to reduce X-Ray disclosed defects to below X% on the next LPG vessel to be constructed, our Group concentrated on the work being performed by about 70 welders. Special attention was paid to the cargo area which requires especially high-quality welds.

3. Setting a Target Value

During analysis of the deficiencies which occurred when building LPG SNo. 2865, eight months before, a Pareto Diagram disclosed that porosity accounted for 50% of the deficiencies and the remainder were due to various other causes, each by significantly lower amounts. With the firm belief of being able to reduce porosity defects by 50% and all other defects collectively also by 50%, targets were set accordingly as 50% of those experienced during construction of SNo. 2865.

4. Analysis of Problems

Group members got together, prepared a Fishbone Diagram which identified problems and their relationships, and exchanged opinions. Conclusions reached were that porosity might be attributable to faulty application of weld sequences and poor fusion might be attributed to improper edge preparations. Also, slag inclusions called for attention to electric-current values.

5. Planning Countermeasures and Execution

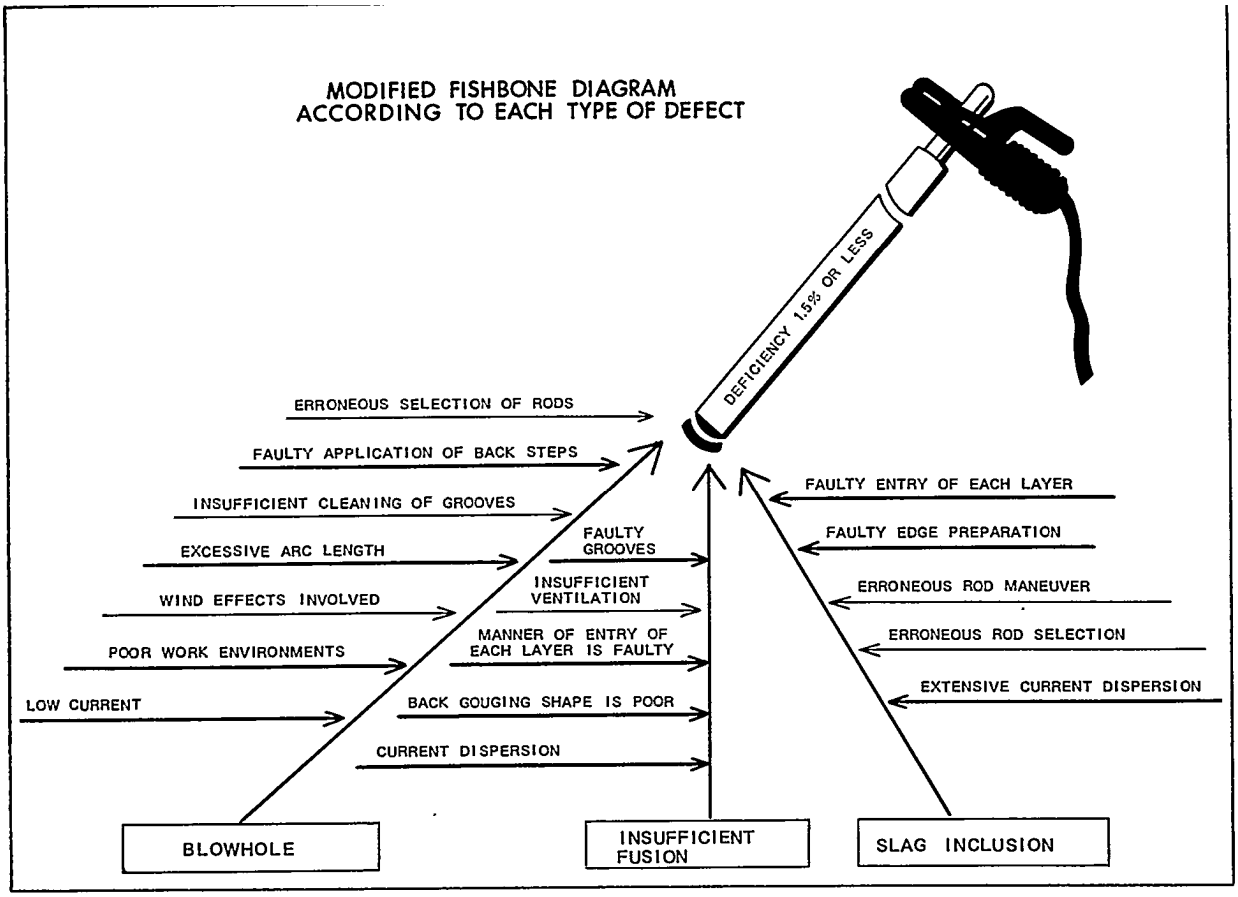
As a result of analysis of causes, it was decided to: (a) conduct training to educate welders on the best range of current values for thin plates, (b) prepare a manual prescribing correct edge preparation and rods to be used for each welding position, and (c) appoint special gap checkers expert enough to guide erection workers.

6. Confirmation of Effects

As a result of the countermeasures, compared with the preceding ship, the deficiency rate reduced from 4.46 to 1.92. Also, rework due to porosity was reduced from 2.20% to 1.30%, faulty fusion from 1.07% to 0.18%, and slag inclusion from 10.0% to 0.39%. Regarding efficiency, an increase of 14% was achieved.

7. Themes for the Future

While experiencing a decrease in quantity, because of reductions in other types of defects, porosity now accounts for 70% of total defects. Thus, in the future all Group members will concentrate their efforts accordingly.



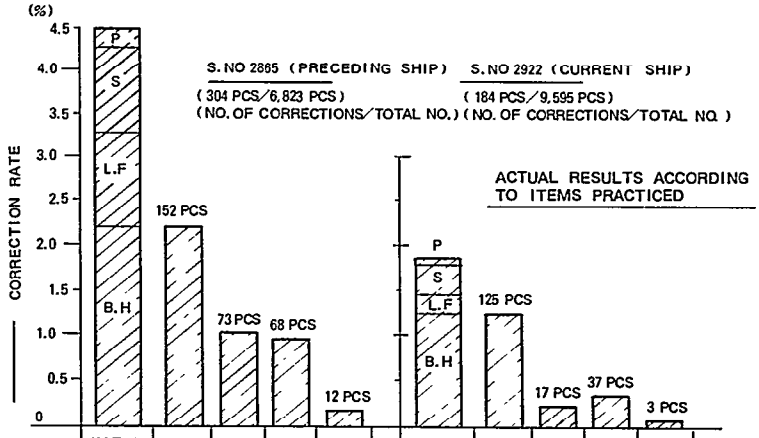
ITEMS PRACTICED

(ADVANCE STUDY & COUNTERMEASURES)

ITEMS	COUNTERMEASURES
THIN PLATE COUNTERMEASURE	GRASPING OF RANGE OF ADEQUATE CURRENT VALUES FOR THIN PLATING ACCORDING TO TRAINING COURSE OF 2 PERSONS/DAY. DURING AUG., SEPT., & OCT., 1984 70 PERSONS FROM EACH JOB AREA (CONFIRMATION BY X-RAY) (APPLICATION MANUAL PREPARED FOR THIN PLATING AND EACH WELDING POSITION)
ROD SELECTION	DISCRIMINATE USE OF POSITIONS (MAG MAGNIFICATION) GROOVE STATE, FILLERS, & WELDING RODS. MANUAL PREPARED
FAULTY EDGE PREPARATION	GROOVE SHECK BY RESPONSIBLE PERSON AND GUIDANCE FOR CUTTING MATCH FOR ERECTION WORKERS.
SHORTAGE OF JIGS & TOOLS	INCREASED INSTALLATION OF GRINDERS, 1 UNIT/PERSON FABRICATION OF ANTI WARP JIGS DESIGN OF HOUSEKEEPING JIGS
FAULTY ENVIRONMENT	BASED ON REFLECTION FOR SNO. 2865 REVIEW OF WORK HOLES WAS CARRIED OUT. ESPECIALLY WEIGHT WAS PLCACED TO PASSABILITY AND VENTILATION ADVANCE CHECK OF DWG WAS CARRIED OUT AND CHANGE MADE. (WORK HOLES TO BE PROVIDED IN PARALLEL BETWEEN SHELL PLATING & TANK PART)
BACK GOUGING SHAPE	OTHER THAN UC SETTING WILL BE MADE ALL BY AIR GUN AND STANDARDIZED TO 5MM IN DEPTH & 10MM IN WIDTH. RECHECK OF WELDING CURRENT
MANNER OF ENTRY OF EACH LAYER	CHECK TO BE CARRIED OUT LAYER BY LAYER AND BEAD CORRECTION BY MEANS OF GR TO BE CARRIED OUT.
GUIDANCE & PATROL BY SPCIALLY APPOINTED PERSON	MANNER OF APPLICATION BY OPERATOR TO BE CHECKED AT SITE AND CORRECTED. OPERATOR TO ENTER VARIOUS CONDITIONS TO CHECK SHEET BY HIMSELF (CURRENT, LOCATION OF APPLICATION, METHOD, AND GROOVE STATE)

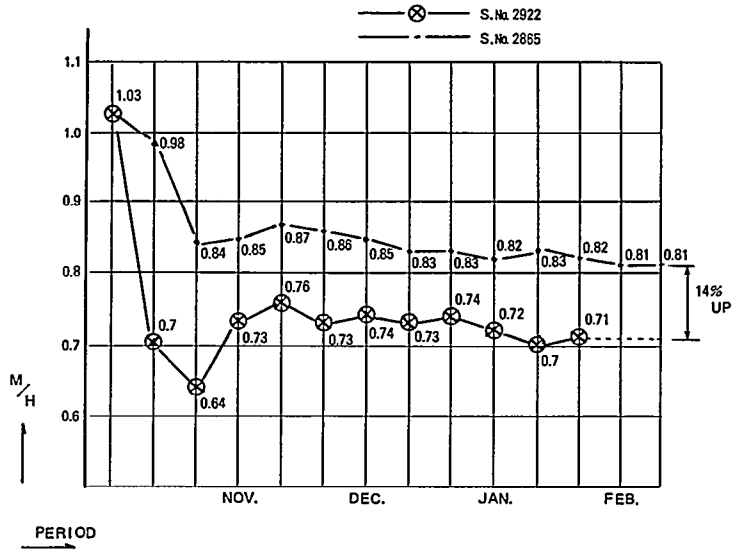
ANALYSIS OF RESULTS

DEFECT BY DEFECT COMPARISON CHART

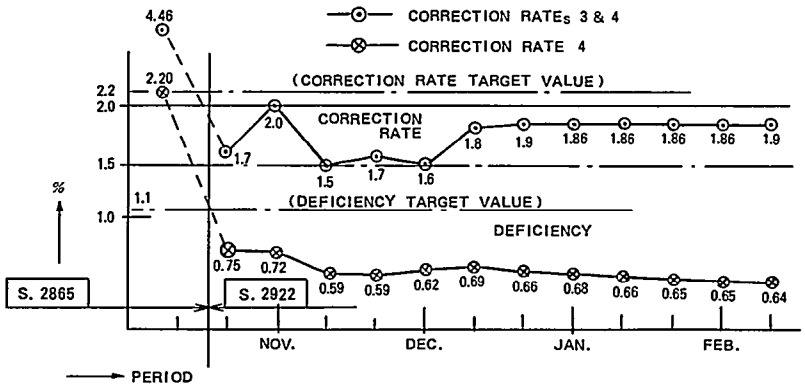


	TOTAL	B.H	L.F	S	P	TOTAL	B.H	L.F	S	P
PERCENTAGE OF CORRECTION RELATIVE TO NO. OF PHOTOS TAKEN	4.46	2.2	1.07	1.00	0.18	1.92	1.30	0.18	0.39	0.03
ACCUMULATED NO. %	100	49.7	24.0	22.4	3.9	100	68.7	9.1	20.5	1.7

COMPARISON BETWEEN SNO.2865 & SNO.2922 ACCORDING TO EFFICIENCY



S. Nº 2922 X-RAY ACCUMULATED



Target: Obtain Improved X-Ray Inspection Results for Erection Welding

1. Summary of Process

Our Group of 10 people is one of the groups that perform erection welding operations. Welding experiences of our members range from 3 to 15 years.

2. Selection of Target

All members of the Group met to discuss the Section's theme (Improve Quality). It was decided to follow this theme by focusing attention on advancing all members' skills, eliminating rework, and adhering to daily schedules. It was agreed that improved X-Ray inspection results would be our theme.

3. Setting the Target Value

Review of pertinent history from the last ship constructed disclosed a deficiency rate of 7.7%. All members agreed in setting a target value of 5% for the first half of 1985 and 3% for the latter half of 1985.

4. Understanding Current Status

In order to acquire more understanding, data was collected from previous ships by kinds of defects, compartments, individuals responsible, etc. The data was carefully studied by all members. The studies disclosed that the difference in skills among members was greater than anyone had suspected and that the bottom and main decks were relatively high in deficiencies. Also, it was found that there are differences in deficiency rates occurring between automatic and semiautomatic welding.

5. Analysis of Problems

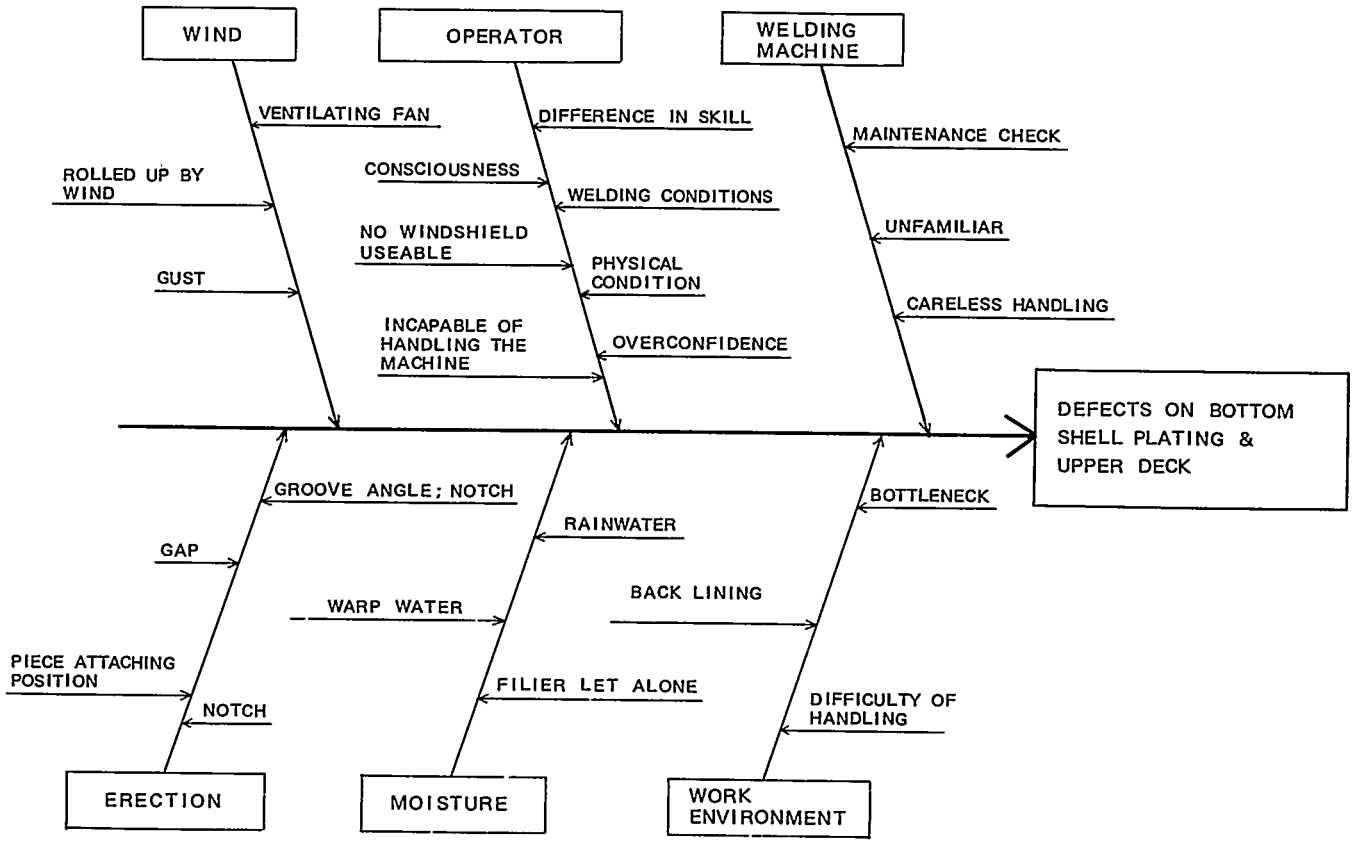
Because of the findings, priority was given to the elimination of deficiencies in the bottom and main deck. Group members identified problems and established their relationships on a Fishbone Diagram.

6. Countermeasures and Execution

Discussions were conducted with the Erection Section people who have responsibility for whatever block trimming is required before blocks are landed in a building dock. Decisions were made to: (a) make more use of automatic cutters in order to improve gap accuracy, (b) minimize the use of temporary members (clips, dogs, etc.) and when necessary specify that their attachment shall be on the side away from the welder, (c) upgrade worker skills, (d) post actual results so as to be visible to all members, (e) display result charts according to individuals, (f) when deficiencies occur discuss causes and countermeasures through personal interviews, and (g) share in checking the results of countermeasures and keeping records.

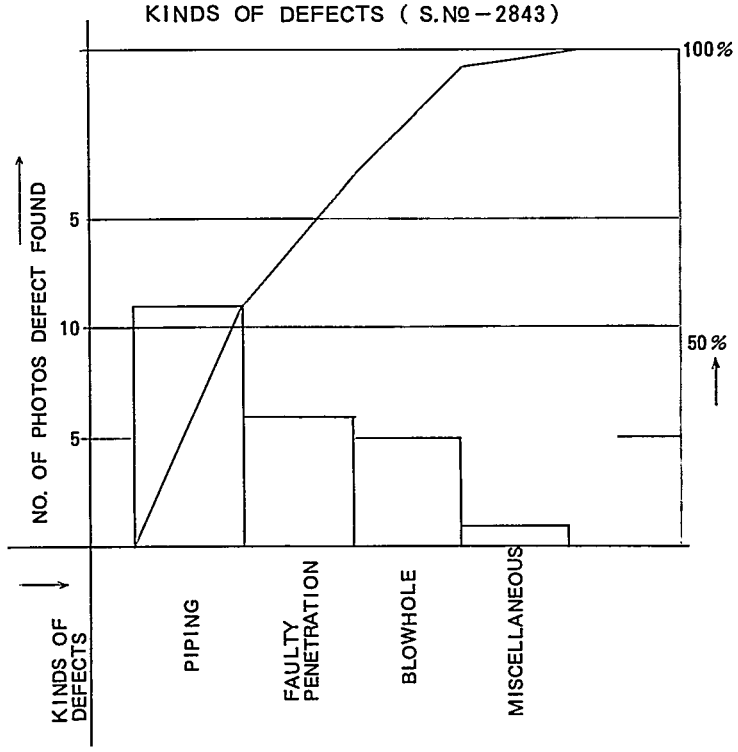
7. Confirmation of results and Policy for the Future

The deficiency rate was reduced to 1.9%. For further improvement, education and training to increase the Group's skills will be repeated and more application will be made of automatic welding at the expense of semiautomatic welding.

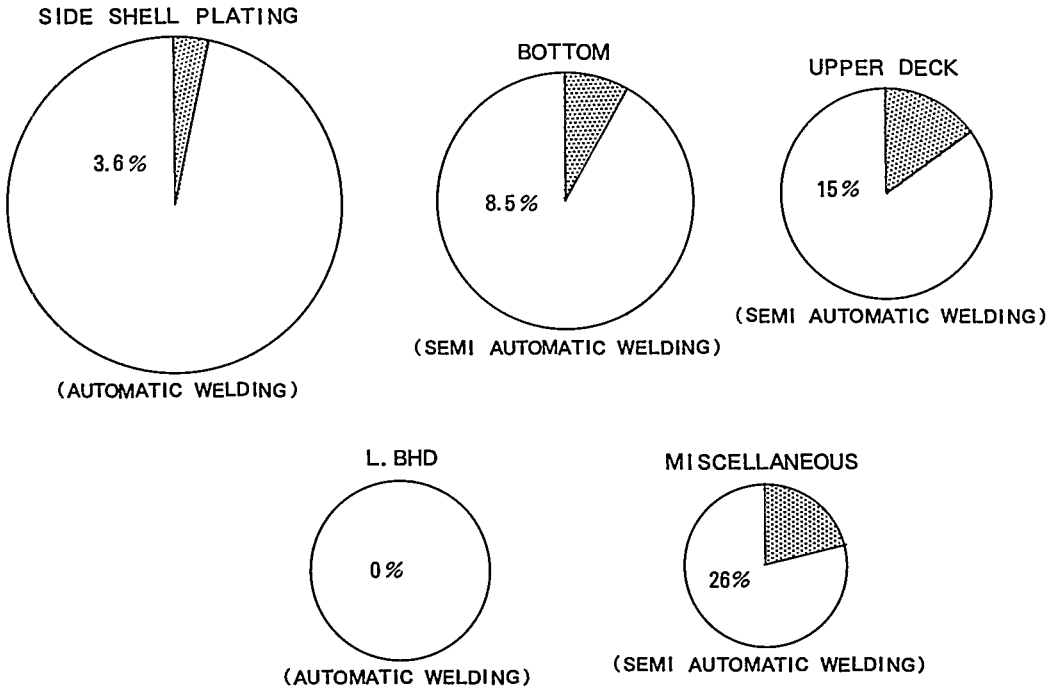


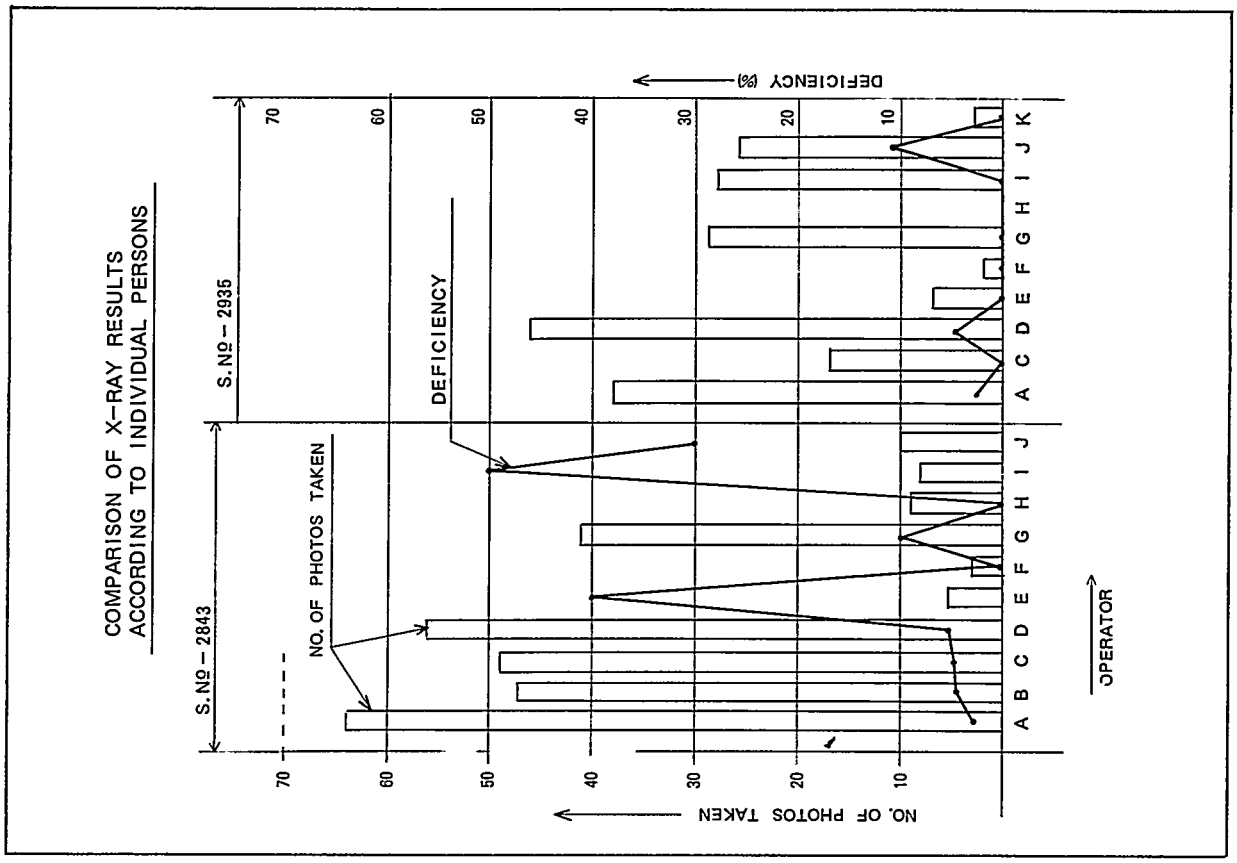
DATA ANALYSIS

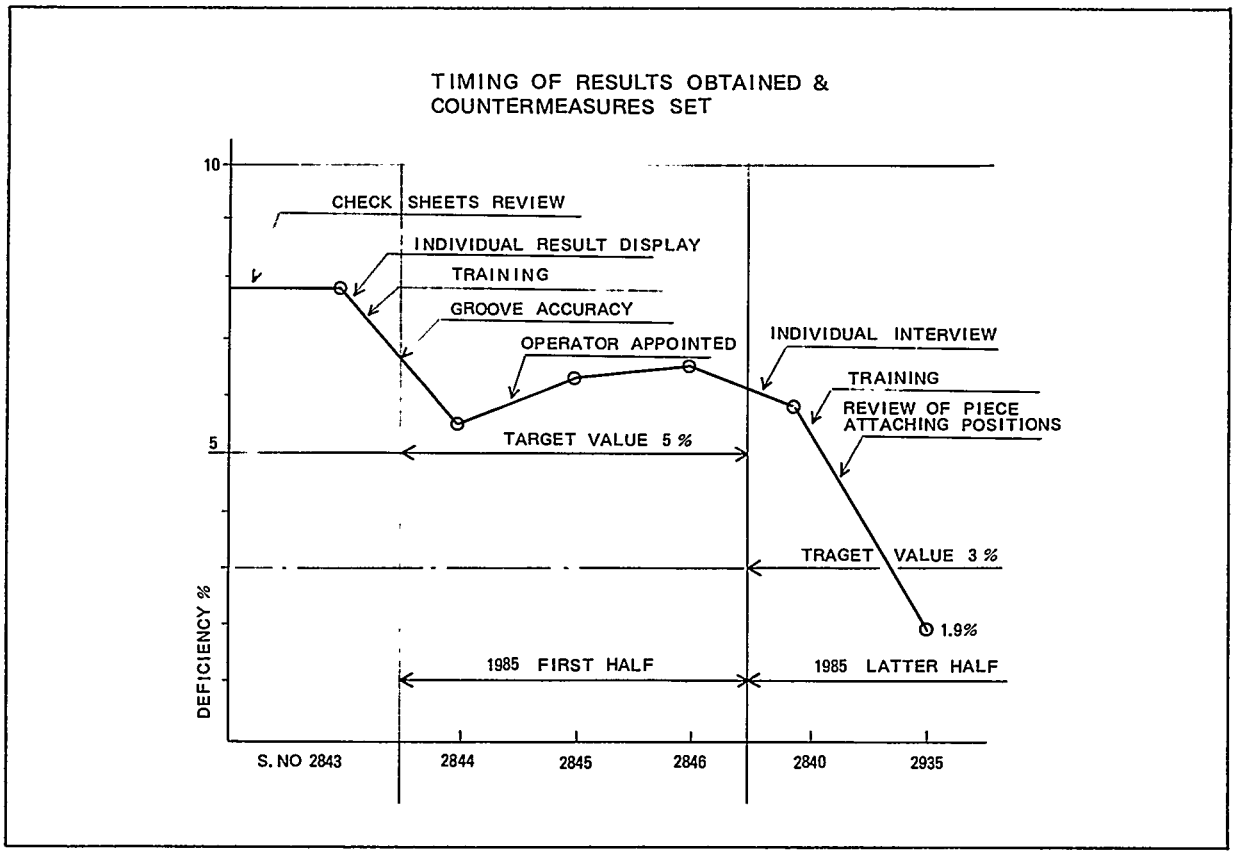
DEFICIENCY RATES ACCORDING TO KINDS OF DEFECTS (S.№-2843)



SNO-2843 X-RAY DEFICIENCY RATES ACCORDING TO COMPARTMENTS




COMPARISON OF X-RAY RESULTS
ACCORDING TO INDIVIDUAL PERSONS
S.№ – 2935
S.№ – 2843
DEFICIENCY
NO. OF PHOTOS TAKEN
DEFICIENCY (%)
NO. OF PHOTOS TAKEN
70
60
50
40
30
20
10
A B C D E F G H I J K
OPERATOR


TIMING OF RESULTS OBTAINED &
COUNTERMEASURES SET
10
5
DEFICIENCY %
CHECK SHEETS REVIEW
INDIVIDUAL RESULT DISPLAY
TRAINING
GROOVE ACCURACY
OPERATOR APPOINTED
INDIVIDUAL INTERVIEW
TRAINING
REVIEW OF PIECE
ATTACHING POSITIONS
TARGET VALUE 5 %
TRAGET VALUE 3 %
1.9%
1985 FIRST HALF
1985 LATTER HALF
S. NO 2843
2844
2845
2846
2840
2935

Target: Save Thermal Energy

1. Process Summary

Our Group is in charge of all power services within the shipyard less electricity. We are responsible for the maintenance and operation of facilities and installation of terminals as required to sustain shipyard operations with gas, compressed air, water, and steam. Our motto is, Closely Relate Supply to Demand.

2. Selection of Target and Setting a Target Value

Our Group met to confer on the Shipyard theme, "Execute Energy Saving Measures". We adopted the same theme and initiated a study of historical data. We realized from a Pareto analysis that gas accounted for 23.5% of total energy costs and that its cost was only exceeded by the cost for electricity for which another group was responsible. A second Pareto Diagram disclosed that, of the various types of gas consumed during the year previous, butane (used to fire the shipyard boilers) accounted for the greatest cost. Thus, the Group decided it could make its best contribution toward fulfilling the Shipyard theme by concentrating on butane consumption and setting a target to reduce cost by 10% as compared with the previous year.

3. Analysis, Countermeasures, and Execution

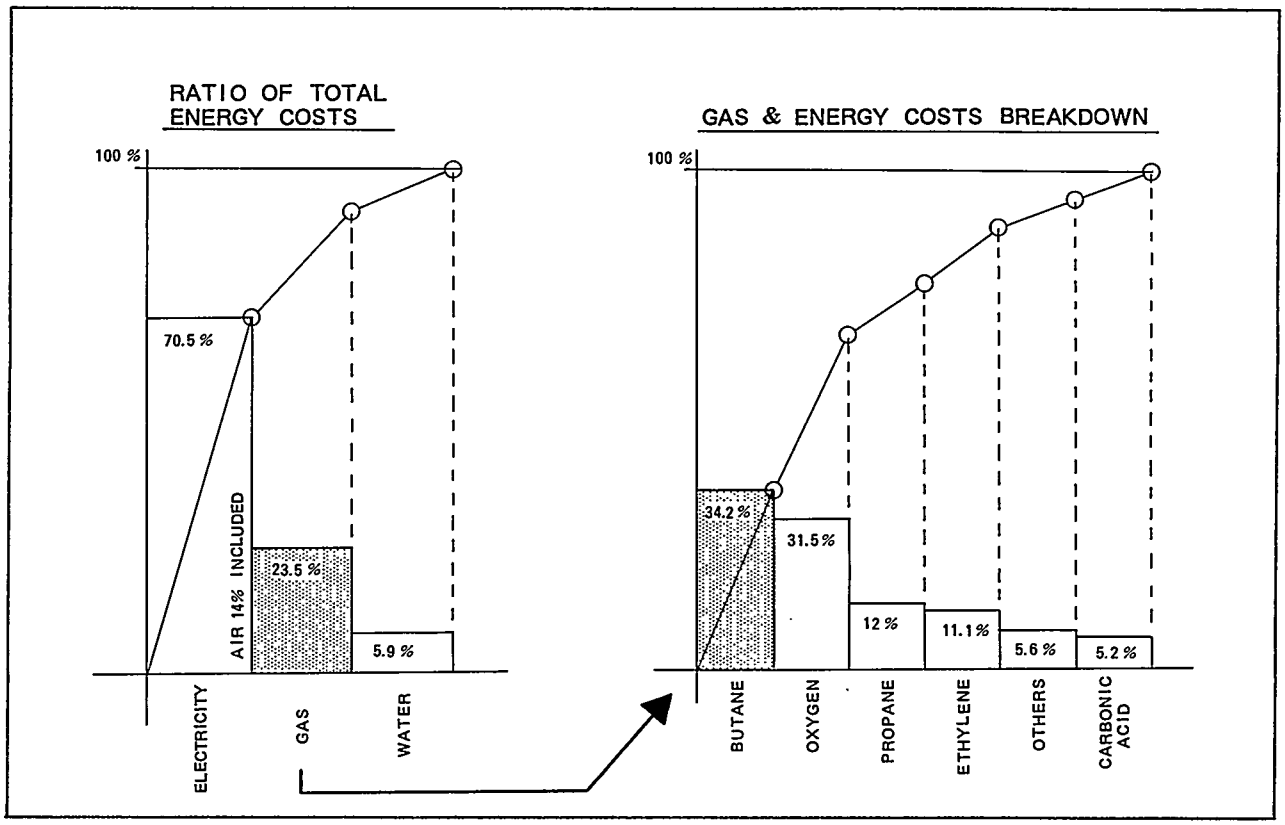
A Fishbone Diagram was used to organize the Group's thoughts about ways to save energy. The consumption records for the previous year for all butane-use locations were examined. In the order of maximum usage, facilities were inspected and remedies for more efficient butane usage were applied, e.g., adjustments, stopping steam leaks, insulating, etc.

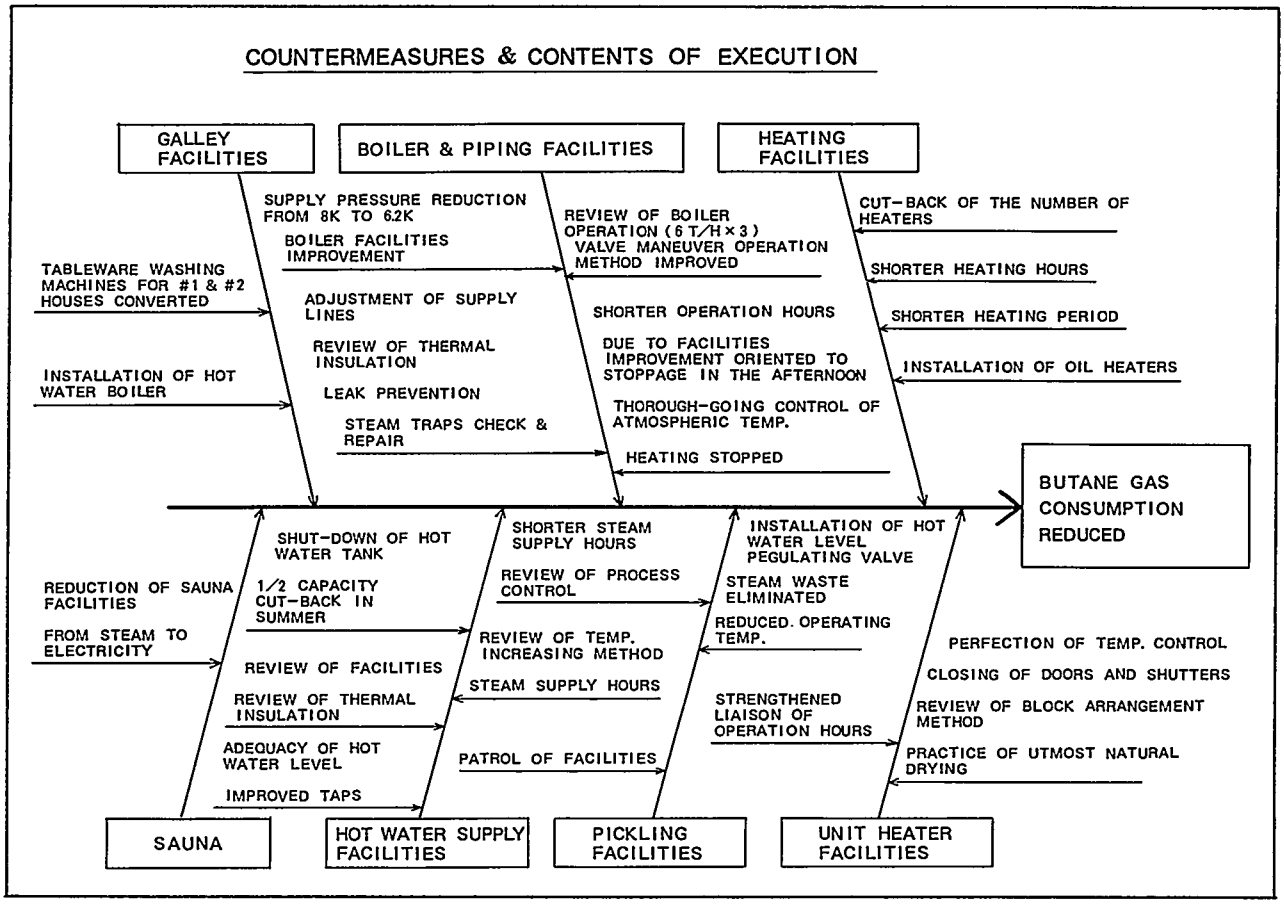
4. Effects

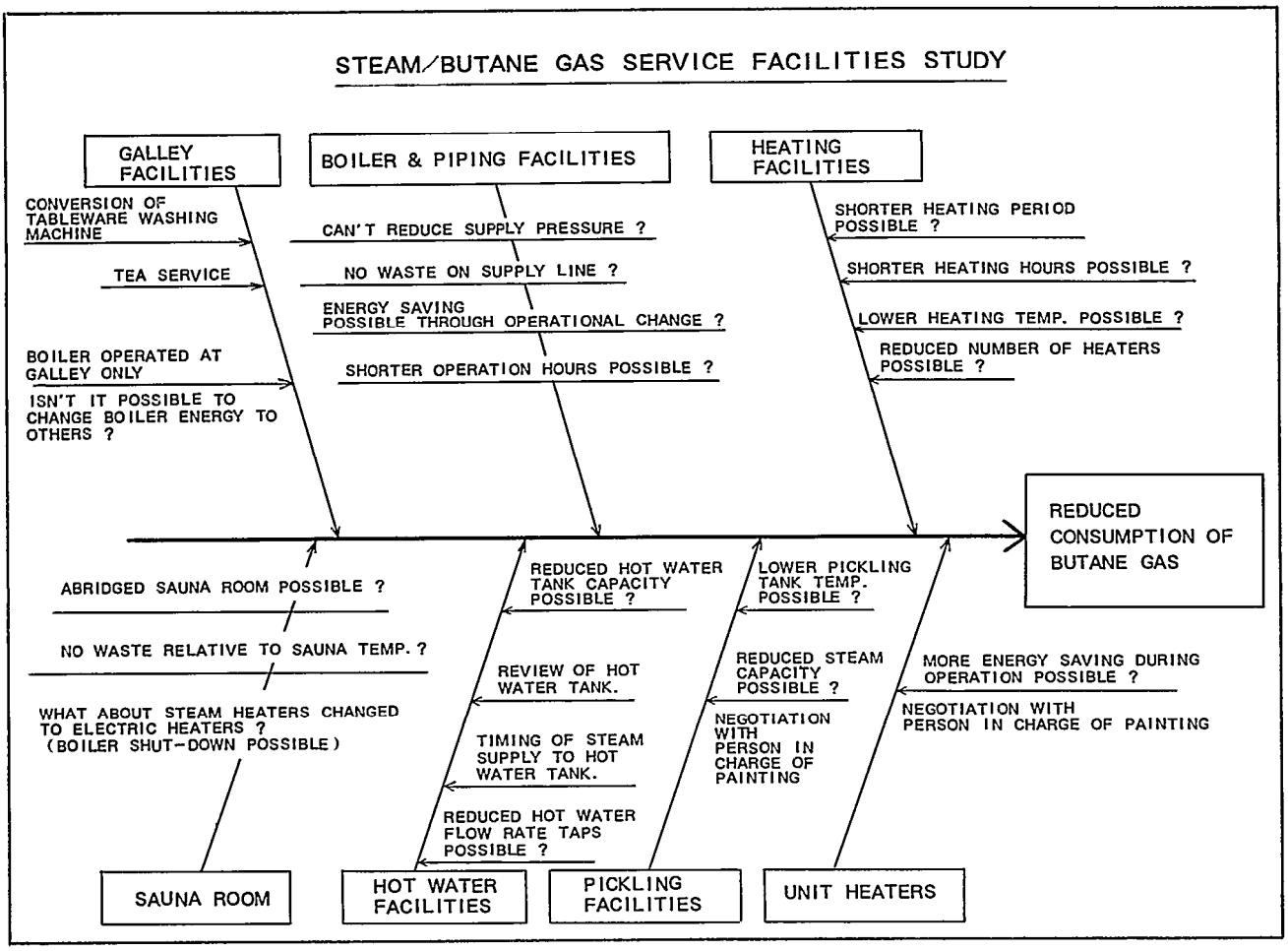
As a consequence of the countermeasures, butane consumption was reduced for both winter and summer seasons. Compared to the preceding year, just the quantity of butane for the boilers was reduced by 22%. The overall reduction for the shipyard was 18.9%. We exceeded our target by 8.9%.

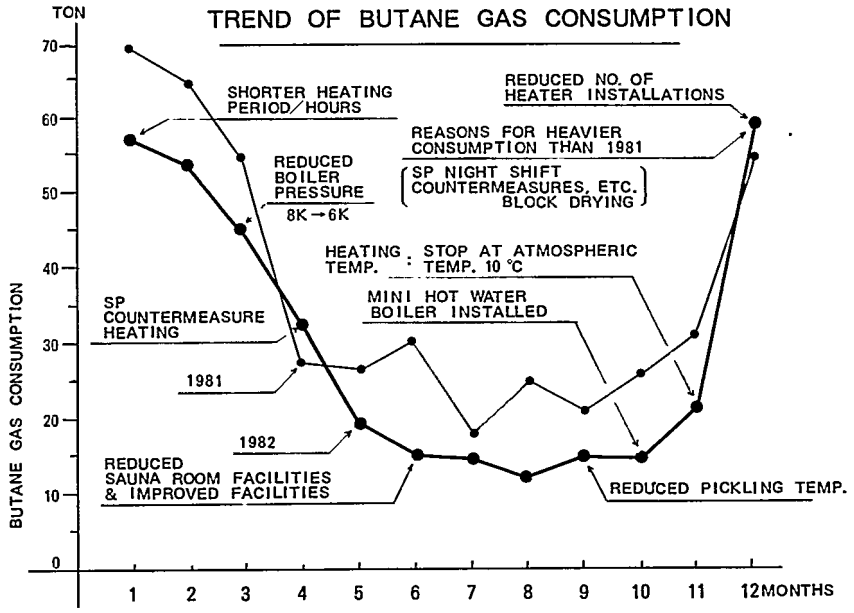
5. Future Problems

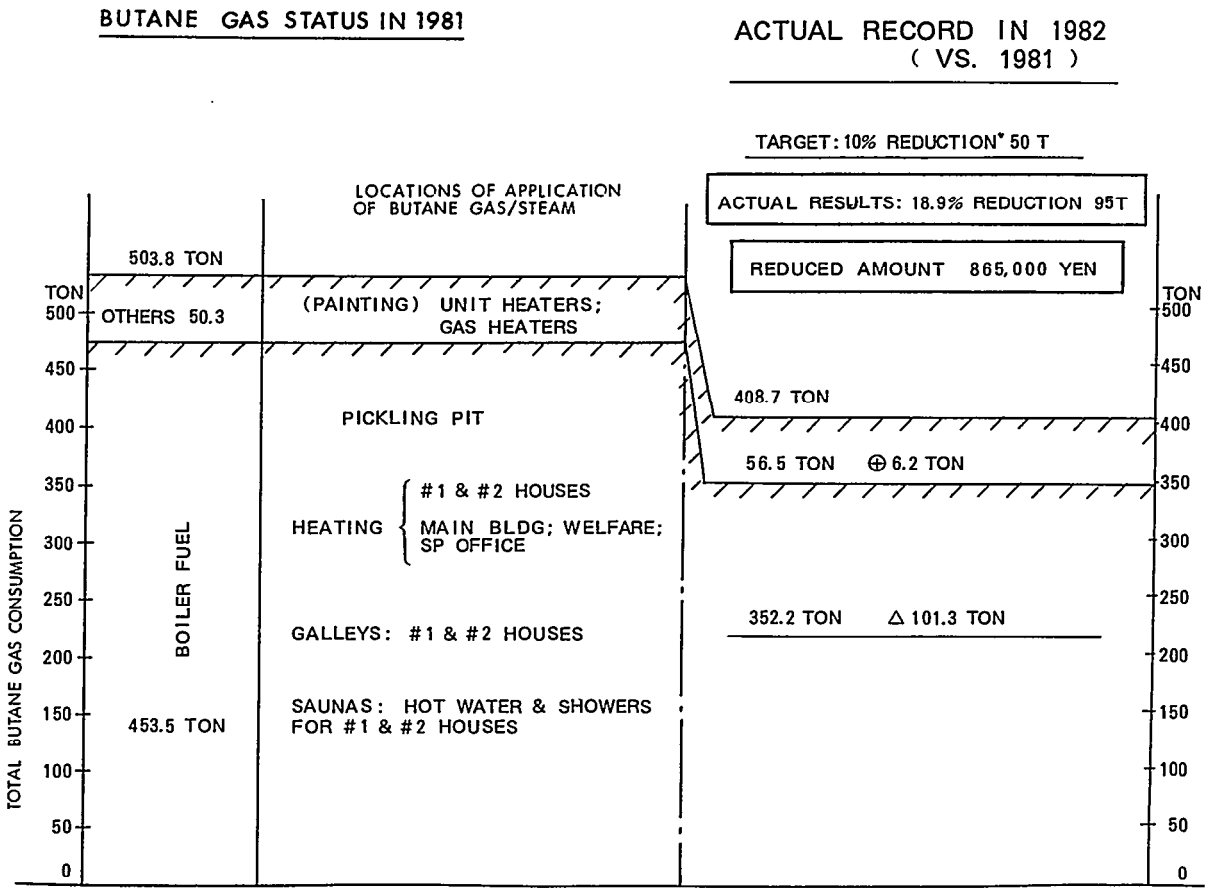
According to our Pareto analysis, energy consumed for compressed-air service accounts for the next largest expenditure. We will set a target, apply the same analysis approach, and respond to countermeasures that surface in hopes of further reducing shipyard energy costs.


RATIO OF TOTAL ENERGY COSTS
100 %
70.5 %
AIR 14% INCLUDED
23.5 %
5.9 %
ELECTRICITY
GAS
WATER
GAS & ENERGY COSTS BREAKDOWN
100 %
34.2 %
31.5 %
12 %
11.1 %
5.6 %
5.2 %
BUTANE
OXYGEN
PROPANE
ETHYLENE
OTHERS
CARBONIC ACID


COUNTERMEASURES & CONTENTS OF EXECUTION
GALLEY FACILITIES
BOILER & PIPING FACILITIES
HEATING FACILITIES
SUPPLY PRESSURE REDUCTION FROM 8K TO 6.2K
BOILER FACILITIES IMPROVEMENT
TABLEWARE WASHING MACHINES FOR #1 & #2 HOUSES CONVERTED
ADJUSTMENT OF SUPPLY LINES
REVIEW OF THERMAL INSULATION
INSTALLATION OF HOT WATER BOILER
LEAK PREVENTION
STEAM TRAPS CHECK & REPAIR
REVIEW OF BOILER OPERATION (6 T/H × 3) VALVE MANEUVER OPERATION METHOD IMPROVED
SHORTER OPERATION HOURS
DUE TO FACILITIES IMPROVEMENT ORIENTED TO STOPPAGE IN THE AFTERNOON
THOROUGH-GOING CONTROL OF ATMOSPHERIC TEMP.
HEATING STOPPED
CUT-BACK OF THE NUMBER OF HEATERS
SHORTER HEATING HOURS
SHORTER HEATING PERIOD
INSTALLATION OF OIL HEATERS
BUTANE GAS CONSUMPTION REDUCED
SHUT-DOWN OF HOT WATER TANK
REDUCTION OF SAUNA FACILITIES
1/2 CAPACITY CUT-BACK IN SUMMER
FROM STEAM TO ELECTRICITY
REVIEW OF FACILITIES
REVIEW OF THERMAL INSULATION
ADEQUACY OF HOT WATER LEVEL
IMPROVED TAPS
SHORTER STEAM SUPPLY HOURS
REVIEW OF PROCESS CONTROL
REVIEW OF TEMP. INCREASING METHOD
STEAM SUPPLY HOURS
PATROL OF FACILITIES
INSTALLATION OF HOT WATER LEVEL PEGULATING VALVE
STEAM WASTE ELIMINATED
REDUCED. OPERATING TEMP.
STRENGTHENED LIAISON OF OPERATION HOURS
PERFECTION OF TEMP. CONTROL
CLOSING OF DOORS AND SHUTTERS
REVIEW OF BLOCK ARRANGEMENT METHOD
PRACTICE OF UTMOST NATURAL DRYING
SAUNA
HOT WATER SUPPLY FACILITIES
PICKLING FACILITIES
UNIT HEATER FACILITIES


STEAM/BUTANE GAS SERVICE FACILITIES STUDY
GALLEY FACILITIES
BOILER & PIPING FACILITIES
HEATING FACILITIES
CONVERSION OF TABLEWARE WASHING MACHINE
TEA SERVICE
BOILER OPERATED AT GALLEY ONLY
ISN'T IT POSSIBLE TO CHANGE BOILER ENERGY TO OTHERS ?
CAN'T REDUCE SUPPLY PRESSURE ?
NO WASTE ON SUPPLY LINE ?
ENERGY SAVING POSSIBLE THROUGH OPERATIONAL CHANGE ?
SHORTER OPERATION HOURS POSSIBLE ?
SHORTER HEATING PERIOD POSSIBLE ?
SHORTER HEATING HOURS POSSIBLE ?
LOWER HEATING TEMP. POSSIBLE ?
REDUCED NUMBER OF HEATERS POSSIBLE ?
REDUCED CONSUMPTION OF BUTANE GAS
ABRIDGED SAUNA ROOM POSSIBLE ?
NO WASTE RELATIVE TO SAUNA TEMP. ?
WHAT ABOUT STEAM HEATERS CHANGED TO ELECTRIC HEATERS ? (BOILER SHUT-DOWN POSSIBLE)
REDUCED HOT WATER TANK CAPACITY POSSIBLE ?
REVIEW OF HOT WATER TANK.
TIMING OF STEAM SUPPLY TO HOT WATER TANK.
REDUCED HOT WATER FLOW RATE TAPS POSSIBLE ?
LOWER PICKLING TANK TEMP. POSSIBLE ?
REDUCED STEAM CAPACITY POSSIBLE ?
NEGOTIATION WITH PERSON IN CHARGE OF PAINTING
MORE ENERGY SAVING DURING OPERATION POSSIBLE ?
NEGOTIATION WITH PERSON IN CHARGE OF PAINTING
SAUNA ROOM
HOT WATER FACILITIES
PICKLING FACILITIES
UNIT HEATERS


TREND OF BUTANE GAS CONSUMPTION
TON
BUTANE GAS CONSUMPTION
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12MONTHS
SHORTER HEATING PERIOD/HOURS
REDUCED NO. OF HEATER INSTALLATIONS
REASONS FOR HEAVIER CONSUMPTION THAN 1981
SP NIGHT SHIFT
COUNTERMEASURES, ETC.
BLOCK DRYING
REDUCED BOILER PRESSURE
8K→6K
HEATING : STOP AT ATMOSPHERIC TEMP. TEMP. 10 °C
MINI HOT WATER BOILER INSTALLED
SP COUNTERMEASURE HEATING
1981
1982
REDUCED SAUNA ROOM FACILITIES & IMPROVED FACILITIES
REDUCED PICKLING TEMP.


BUTANE GAS STATUS IN 1981
ACTUAL RECORD IN 1982
(VS. 1981)
TARGET: 10% REDUCTION* 50 T
ACTUAL RESULTS: 18.9% REDUCTION 95T
REDUCED AMOUNT 865,000 YEN
LOCATIONS OF APPLICATION OF BUTANE GAS/STEAM
503.8 TON
TON
500
OTHERS 50.3
(PAINTING) UNIT HEATERS; GAS HEATERS
450
PICKLING PIT
408.7 TON
400
56.5 TON ⊕ 6.2 TON
350
HEATING { #1 & #2 HOUSES; MAIN BLDG; WELFARE; SP OFFICE
300
250
352.2 TON △ 101.3 TON
GALLEYS: #1 & #2 HOUSES
200
150
SAUNAS: HOT WATER & SHOWERS FOR #1 & #2 HOUSES
453.5 TON
100
50
0
BOILER FUEL
TOTAL BUTANE GAS CONSUMPTION

Target: Improve Distortion Removal Efficiency

1. Process Summary

In our shipyard, the Accommodation Fitting Section is responsible for ground assembly of deckhouses. Our Group is responsible for removing distortion from steel bulkheads and decks after blocks are welded together. In the past, the same people who fitted and welded the blocks together were also responsible for distortion removal. This approach made distortion removal a secondary operation which often caused conflicts with following work teams. Thus, our group members were assigned to be fully engaged in distortion removal from ground assembly of each deckhouse to post installation on board.

2. Selecting and Setting a Target

Since our Group is responsible for distortion removal during a number of stages, we decided to establish as our first target, “Improve Efficiency of Distortion Removal During Ground Assembly”. We agreed to aim for a 3% increase in efficiency.

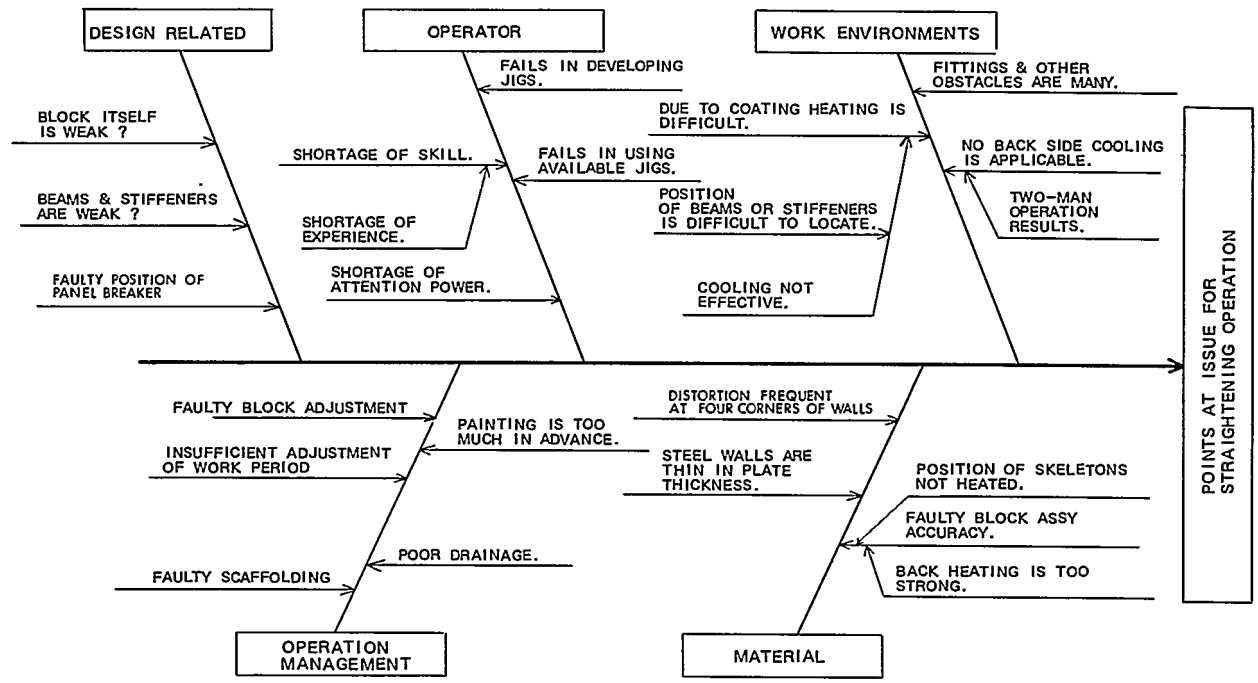
3. Analysis, Countermeasures, and Execution

At a Group meeting we identified problems, organized them on a Fishbone Diagram, and proposed countermeasures. Problems with block accuracy and thin plates were highlighted and details of fabrication and assembly procedures were investigated. A conference was conducted with people from design and previous work processes concerning accuracy. Also, a review was made of bulkhead stiffening and feedback was sent to design for further study. Joint meetings were also held with groups for ground assembly and painting work.

4. Effects and the Future

The 3.5% increase in efficiency, compared to the previous ship, was achieved. In the future we will organize to assign responsibility for maintaining the status of each block to an individual Group member. Also, the better techniques we developed for removing distortion during ground assembly, will be applied after each deckhouse is landed on board.

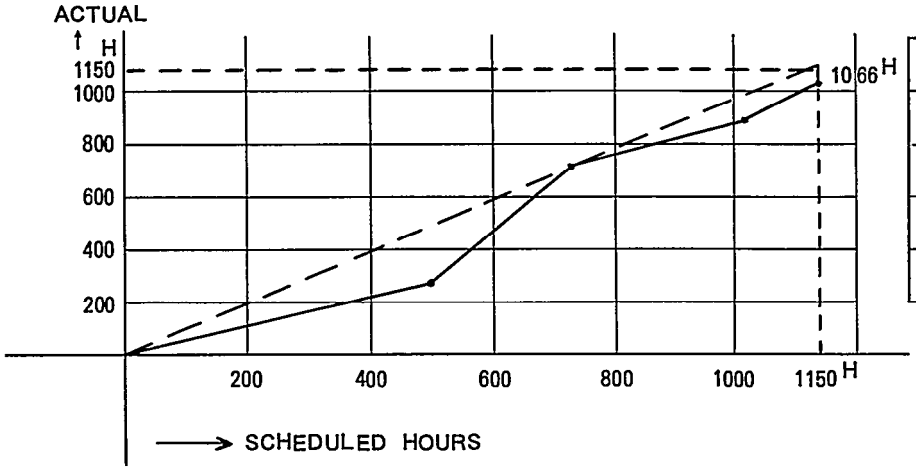
POINTS AT ISSUE ADJUSTED ACCORDING TO FISHBONE CHART



POINTS AT ISSUE & THEIR COUNTERMEASURES

POINTS AT ISSUE	COUNTERMEASURES	PSERSON TO EXECUTE
1. BLOCK ACCURACY	REVIEW OF ACCURACY CRITERIA APPLICABLE TO BLOCK ASSY OPERATION.	F
	INVESTIGATION OF ACCURACY OF BLOCK ASSY SURFACE PLATE.	F
	REVIEW OF PROCEDURE FOR BACK HEATING.	LEADER
2. DISTORTION DUE TO THIN PLATES	TRY TO CHANGE POSITION OF PANEL BRAKER INSTALLATION.	DESIGN
	TRY TO INSTALL ANTI WARP MATERIALS TO FOUR CORNERS OF WALLS.	DESIGN
	TRY TO CHANGE PLATE THICKNESS OF WALL SKELETONS.	DESIGN
3. RELATION WITH COATING	HOLD CONFERENCE WITH PAINTING SECT AND PART OF UNDERCOATING OF WALL WILL BE APPLIED DURING LATER STAGE OF PROCESS.	PAINTING
4. PROBLEM OF OPERATORS	PERSONAL EFFICIENCY GRAPHS WILL BE PREPARED AND POINTS AT ISSUE WILL BE HIGHLIGHTED.	GROUP MEMBERS
	RESPONSIBLE PERSON FOR BLOCKS WILL BE APPOINTED WHO TAKES RESPONSIBILITY UNTIL INSPECTION FINISHED.	RESPONSIBLE PERSON FOR BLOCKS
	FOR MAINTENANCE OF STRAIGHTENING MACHINE, ETC., JIGS WILL BE USED.	GROUP MEMBERS
5. OPERATIONAL MANAGEMENT SYSTEM	ADJUSTMENT BETWEEN WELDERS JOB AND PAINTERS JOB TO BE MADE IN MORE DETAIL.	F
	NO FITTING ITEMS TO BE LEFT PLACED DIRECTLY ON DECK.	F

SCHEDULE & ACTUAL HOURS COMPARISON



	SCHEDULE	ACTUAL
6/30	504 H	281 H
7/10	731 H	770 H
7/20	1022 H	942 H
7/30	1150 H	1066 H

Target: Reduce On-Board Welding Man-Hours

1. Process Summary

Our Group is responsible for welding engine-room fittings on board.

2. Selection and Setting a Target

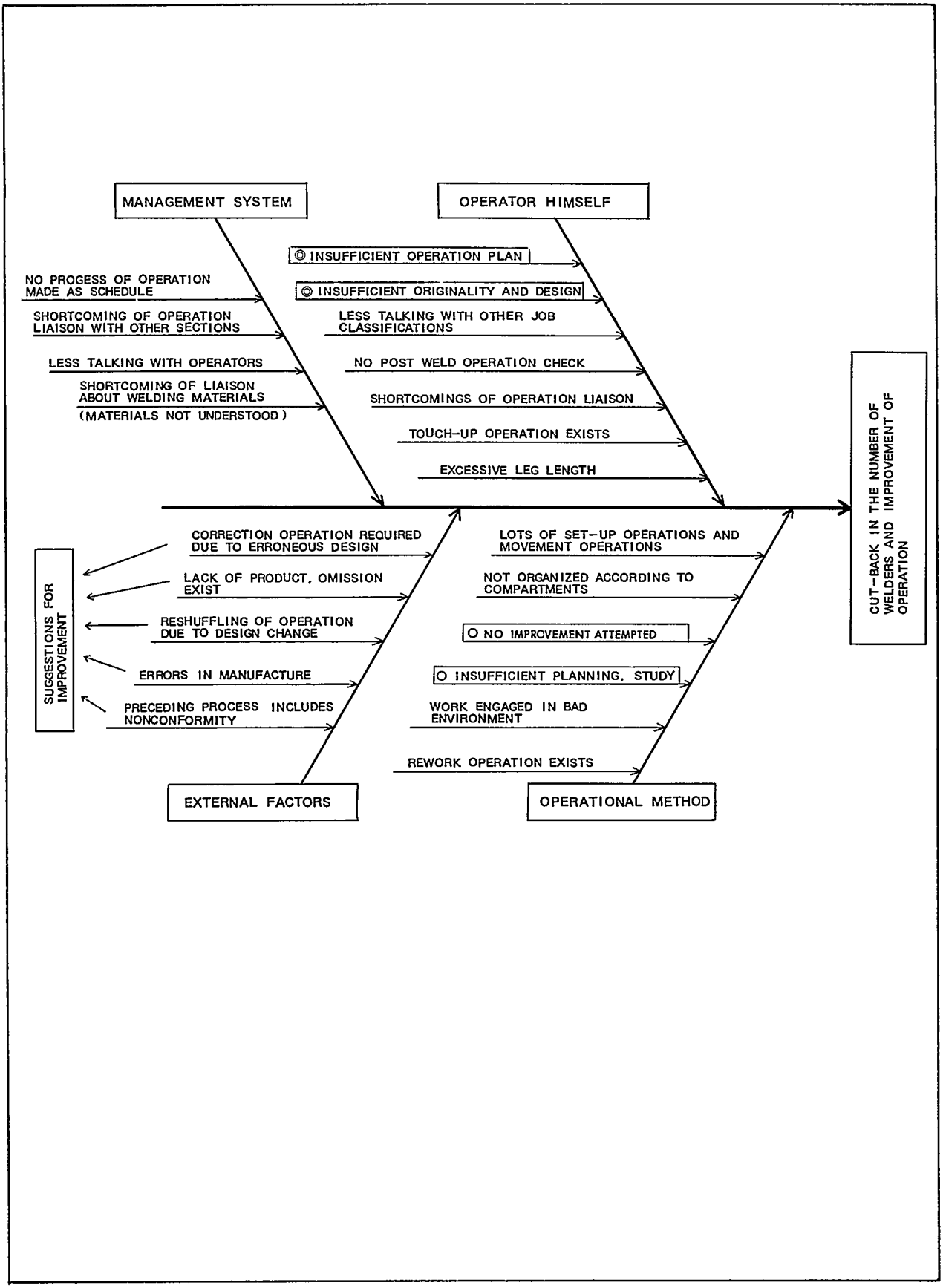
Our work involves fitting make-up pieces and such other miscellaneous tasks that could not be finish welded on-unit or on-block. The custom nature of the work defies the degrees of systematic control that are possible with other types of work. Thus, in line with the Section target "Reduce Man-Hours", we established "Cut Back On-Board Welding Man-Hours" as our target, and per further discussion in a Group meeting, estimated that a 5% reduction was possible. It was also decided that man-hours would be controlled by ourselves, individually.

3. Analysis, Countermeasures, and Execution

At a Group meeting, we identified problems, drew a Fishbone Diagram, and organized the problems accordingly. We concluded that each of us had not been much concerned with operational plans and that we lacked originality. Thus, we decided that at each Group meeting we would review monthly and ship-by-ship work plans and estimated man-hours for the Group that are derived from the Section work plan, with the idea of proposing amendments. Also, it was decided that for the purpose of eliminating waste in daily work, a check sheet will be employed and entries will be made daily.

4. Effects and the Future

As a result of Group members earnestly tackling voluntary control of man-hours and demonstrating originality, our actual man-hours were 91.0% of estimated man-hours (842H/925H) in SNO. 2781 and 91.3% (808H/885H) for SNO. 2789. For the future we desire to continue to maintain man-hour control ourselves and tackle more challenging targets. For those purposes it will be necessary to improve certain welding and operating methods including some employed by other groups. We will also have to focus on eliminating errors committed by ourselves.


MANAGEMENT SYSTEM
OPERATOR HIMSELF
◎ INSUFFICIENT OPERATION PLAN
NO PROGESS OF OPERATION MADE AS SCHEDULE
◎ INSUFFICIENT ORIGINALITY AND DESIGN
SHORTCOMING OF OPERATION LIAISON WITH OTHER SECTIONS
LESS TALKING WITH OTHER JOB CLASSIFICATIONS
LESS TALKING WITH OPERATORS
NO POST WELD OPERATION CHECK
SHORTCOMING OF LIAISON ABOUT WELDING MATERIALS (MATERIALS NOT UNDERSTOOD)
SHORTCOMINGS OF OPERATION LIAISON
TOUCH-UP OPERATION EXISTS
EXCESSIVE LEG LENGTH
CUT-BACK IN THE NUMBER OF WELDERS AND IMPROVEMENT OF OPERATION
SUGGESTIONS FOR IMPROVEMENT
CORRECTION OPERATION REQUIRED DUE TO ERRONEOUS DESIGN
LOTS OF SET-UP OPERATIONS AND MOVEMENT OPERATIONS
LACK OF PRODUCT, OMISSION EXIST
NOT ORGANIZED ACCORDING TO COMPARTMENTS
RESHUFFLING OF OPERATION DUE TO DESIGN CHANGE
O NO IMPROVEMENT ATTEMPTED
ERRORS IN MANUFACTURE
O INSUFFICIENT PLANNING, STUDY
PRECEDING PROCESS INCLUDES NONCONFORMITY
WORK ENGAGED IN BAD ENVIRONMENT
REWORK OPERATION EXISTS
EXTERNAL FACTORS
OPERATIONAL METHOD

Target: Reduce Lost Work and Time on the
Medium- and Large-Bore Pipe Piece Fabrication Line

1. Process Summary

Our Group is in charge of marking, cutting, assembling, welding, and finishing as required for producing medium- and large-diameter pipe pieces.

2. Selection and Setting Target

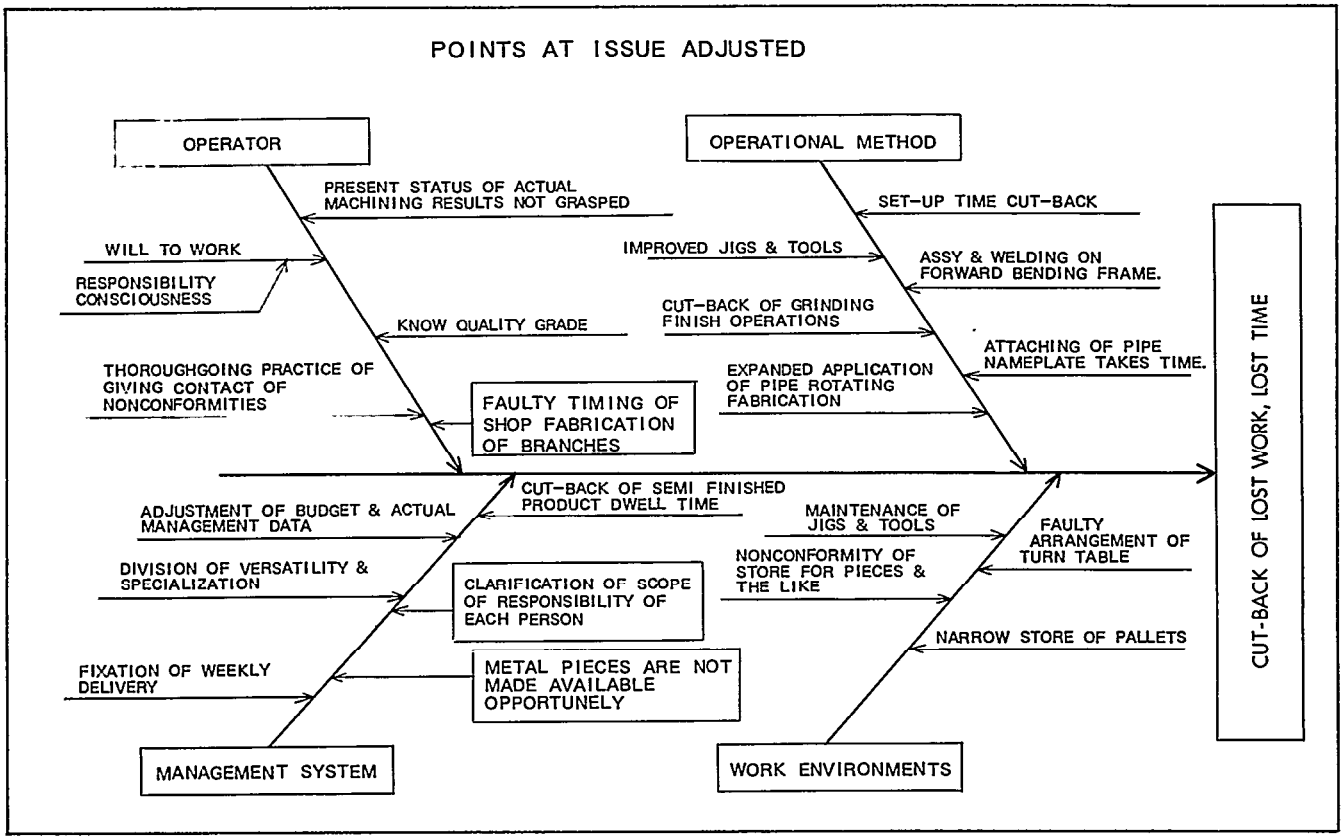
Our Group elected to use the same theme employed by the Shop, i.e., "Reduce Lost Work and Time". We aimed at an increase in efficiency of about 20% by expressing as a target our goal to insure that man-hours actually used should never be more than 1.1 times what the Shop manager budgeted for us.

3. Countermeasures and Implementation

The Group suballocated the Shop manager's budget to each member. Actual time used will be summed and compared accordingly. Differences should indicate potential problems that will be studied. At the same time, improved jigs and fixtures will be considered as basis for lowering the estimates. We used a Fishbone Diagram to show areas that could be more efficient. Of these the ones given the most weight were: (a) Attachment Metal Pieces (ells, tees, etc.) Are Not Available in Time for Pipe Piece Fabrication, (b) Clarification of Operation Responsibility Scope, and (c) Poor Timing of Shop Fabrication of Branch Pipes Generates Idle labor. Countermeasures were formulated and put into practice.

4. Effects and the Future

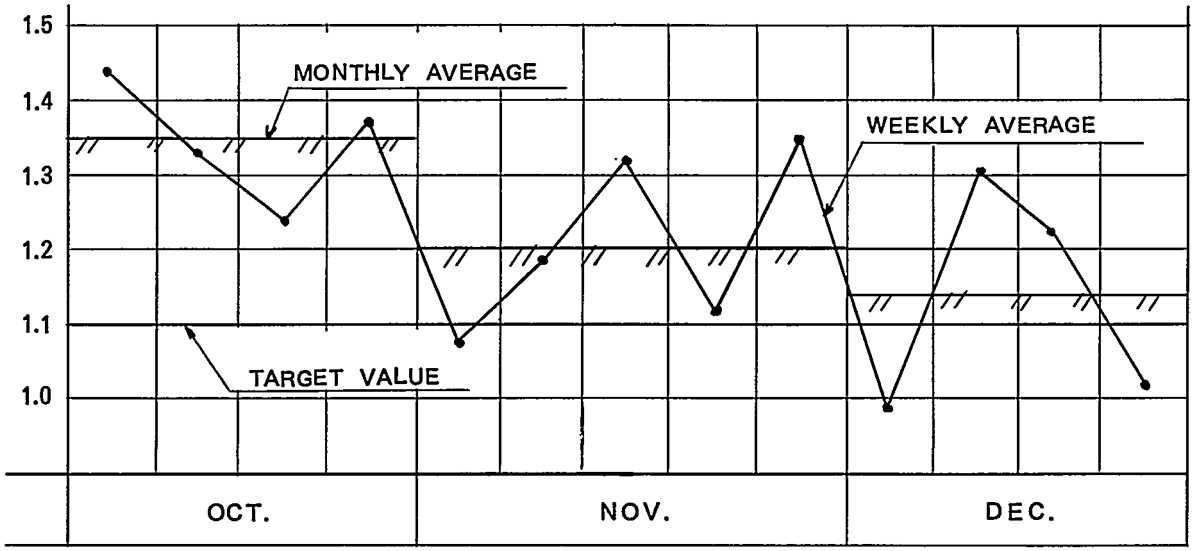
As a result of the countermeasures, it became possible to separate losses generated by an operator from those due to other causes. This yielded a better understanding of how work processes were performing. After three months of operation our target value is about to be achieved. In the future we will expand our attention beyond the three problems for which we now have countermeasures in place. We will examine lost time in more detail and eliminate causes one by one. The data fed back will be used to refine estimates for future work.



WEIGHTED POINTS PRACTICE ITEMS & COUNTERMEASURES

WEIGHTED POINTS PRACTICE ITEMS	COUNTERMEASURES	NOTATION
1) ELLS, TEES, ETC. ARE NOT AVAILABLE IN TIME FOR PIPE PIECE FABRICATION	○ MISSING ITEMS INFORMATION FOR WORK 2 WKS AHEAD WILL BE MADE KNOWN EACH FRIDAY ○ THE INFORMATION WILL BE MADE KNOWN TO EVERYBODY AT A GROUP MEETING ○ ONLY PIPE PIECES FOR WHICH ELLS, TEES, ETC. ARE AVAILABLE WILL BE SCHEDULED FOR FABRICATION	NUMBER OF MISSING / 250 PCS/WK = 15 PCS/WK LOST TIME LOOKING FOR MISSING ELLS, TEES, ETC. → 130^{MIN} ~ 150^{MIN}/WEEK
2) CLARIFICATION OF OPERATION RESPONSIBILITY SCOPE	○ ON THE STRAIGHT PIPE LINE INTEGRATED OPERATION OF ASSY & WELDING OF BRANCHES WILL BE PERFORMED. ○ AFTERWARDS FINAL ASSY WELDING OPERATION WILL BE PERFORMED (CUT-BACK OF WELDING TIME THROUGH UTILIZATION OF TURN TABLE)	PRE ASSEMBLY
3) POOR TIMING OF SHOP FABRICATION OF BRANCH PIPES GENERATES IDLE LABOR	○ BRANCH PIPE SHOP FABRICATION CAPACITY TO BE GRASPED AND OPERATION TO BE QUANTITATIVELY ADJUSTED. ○ EXPANDED USE OF STANDARD PRODUCTS AND ADOPTION OF STOCK SYSTEM. ○ AFTER CUTTING OF PIPES CONFIRMATION OF ACCURACY TO BE PERFORMED POSITIVELY.	STOCK SYSTEM FOR STANDARD PIPE BRANCHES TO BE STUDIED.

PERFORMANCE TRANSITION CURVE



Target: Challenge Welding Efficiency

1. Process Summary

Our Group is engaged in fabrication of materials, needed by the Subassembly and Assembly Section.

2. Selecting and Setting a Target

In selecting our target we carried out an analysis by dividing our problems into two areas, fitting and welding. The studies showed that if certain group members performed only fitting and others performed only welding, work flow would be impaired with a loss of up to 17%. Thus, we proposed to eliminate lost time by training all Group-members in the technical skills needed for both fitting and welding. At the same time, we decided to challenge our welding efficiency of 5.0 meters/man-hour (M/H), achieved for the last ship constructed, by establishing a target of 5.5 M/H for the next ship to be constructed.

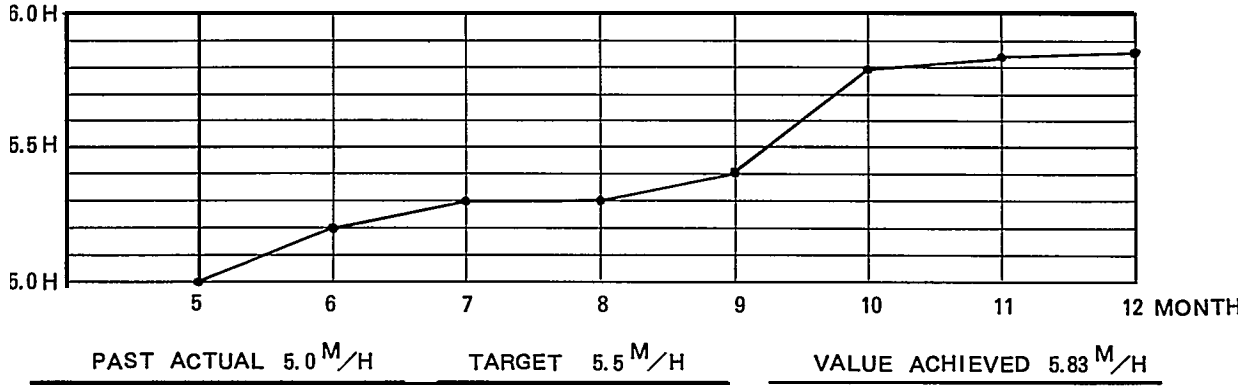
3. Analysis, Planning, and Implementation

A Pareto analysis applied for weighing welding problems disclosed that overlapping is the most frequent problem encountered. The problem was the subject of a Group meeting and a pertinent improvement plan was formulated and subsequently put into practice.

4. Effects and the Future

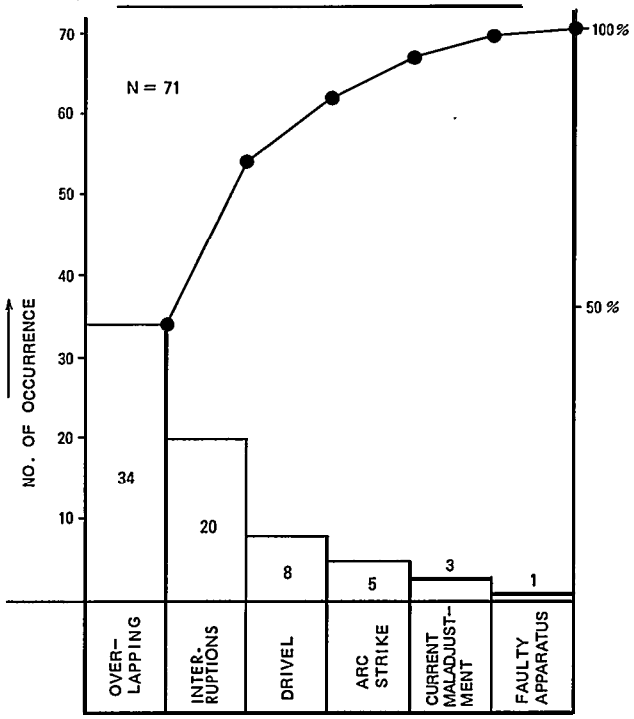
Because of the dual approaches, i.e., developing both fitter and welder skills in each Group member, and the new practices to minimize overlapping, we achieved our target in the fifth month. The improved methods will be incorporated as operational standards. Also, guidance will be given to individuals every day to continually upgrade both their fitting and welding skills .

TARGETS ACHIEVED



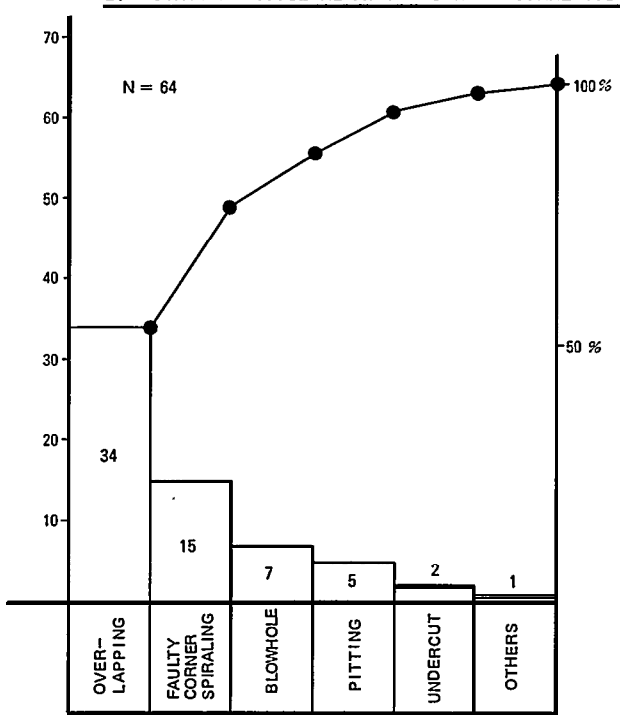
WELDING OPERATION NONCONFORMITIES

A. POINTS AT ISSUE FOR GRAVITY WELDING



OVERLAPPING AND LEFT OVER HEATING ACCOUNT FOR THE MAJORITY.

B. POINTS AT ISSUE RELATIVE TO WELD CORRECTION

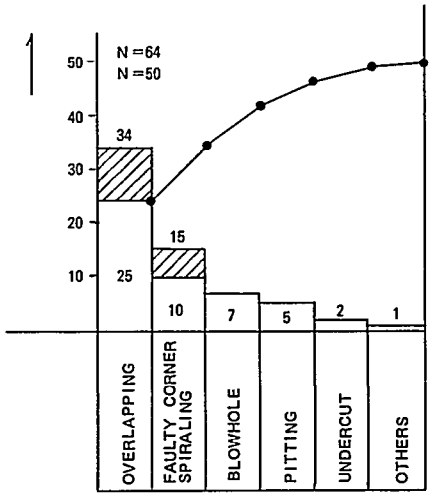


OVERLAPPING AND FAULTY CORNER SPIRALING ACCOUNT FOR 75% OF TOTAL.

REDUCED NUMBER OF LOCATIONS OF CORRECTION DUE TO IMPROVED WELDING STEPS

ITEMS OF IMPROVEMENT IMPLEMENTED

- TACK WELDING RODS MADE TO BE UNIFORM 3.2ϕ RODS AND TACK WELD BEADS IMPROVED TO BE ELONGATED TO A FINE LINE.
- LOCATIONS OF TACK WELDS HELD TO BE OF MINIMUM NUMBER MAKING THEM OF 700 mm PITCH.
- AS FOR GRAVITY PRACTICE HAS BEEN IMPROVED AND UNIFIED TO BE OF SAME DIRECTION WHEN WELDING.
- GRAVITY ROD JOINING METHOD HAS BEEN MADE UNIFORM AND IMPROVED TO BE OF BACK RETURN METHOD.
- CHECK SHEET IS PREPARED AND NUMBER OF NONCONFORMITY OCCURRENCES RELATIVE TO OPERATION OF EACH INDIVIDUAL DUTY HAS BEEN CHECKED.



HATCHED AREA SHOWS REDUCTION AMOUNT.

Target: Reduce Temporary Fitting Pieces (dogs, clips, etc.)

1. Process Summary

Our Group is responsible for fitting work, including tacking, during hull block assembly.

2. Selecting and Setting a Target

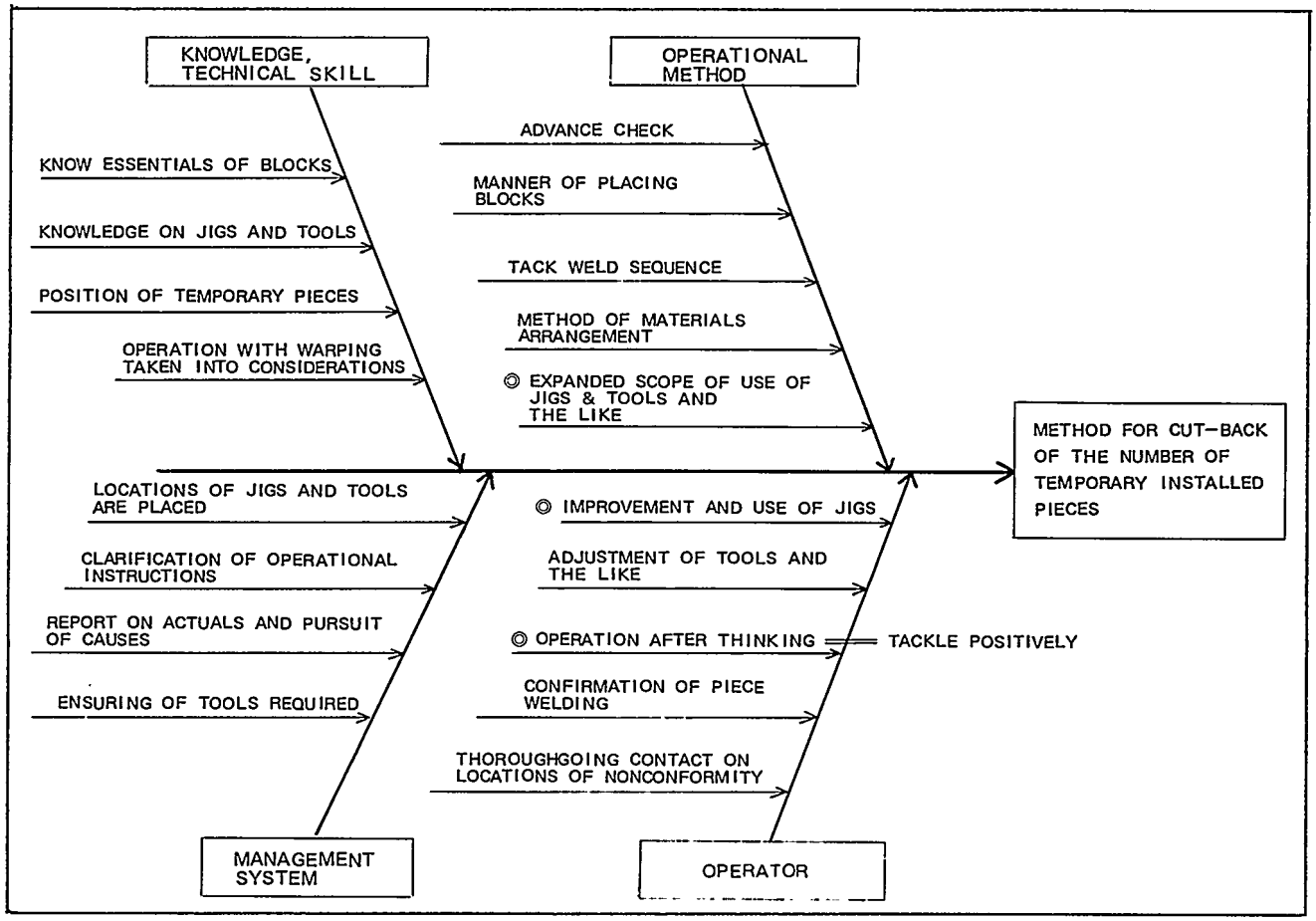
Themes set forth by the Subassembly and Assembly Section are: Reduce Rework, Improve Fitting and Welding Efficiencies, and Save Materials. Our Group considered as themes: Make Erroneous Tack Welds Zero, Make Flaws Due to Gas Cutting Zero, Use Welding Rods Until They are **50 mm** in length or Shorter, and Reduce Temporary Fitting Pieces. We selected the latter as a target. Since we were achieving a weld length of 7 meters for each temporary piece, we set our target as 12 meters/temporary piece.

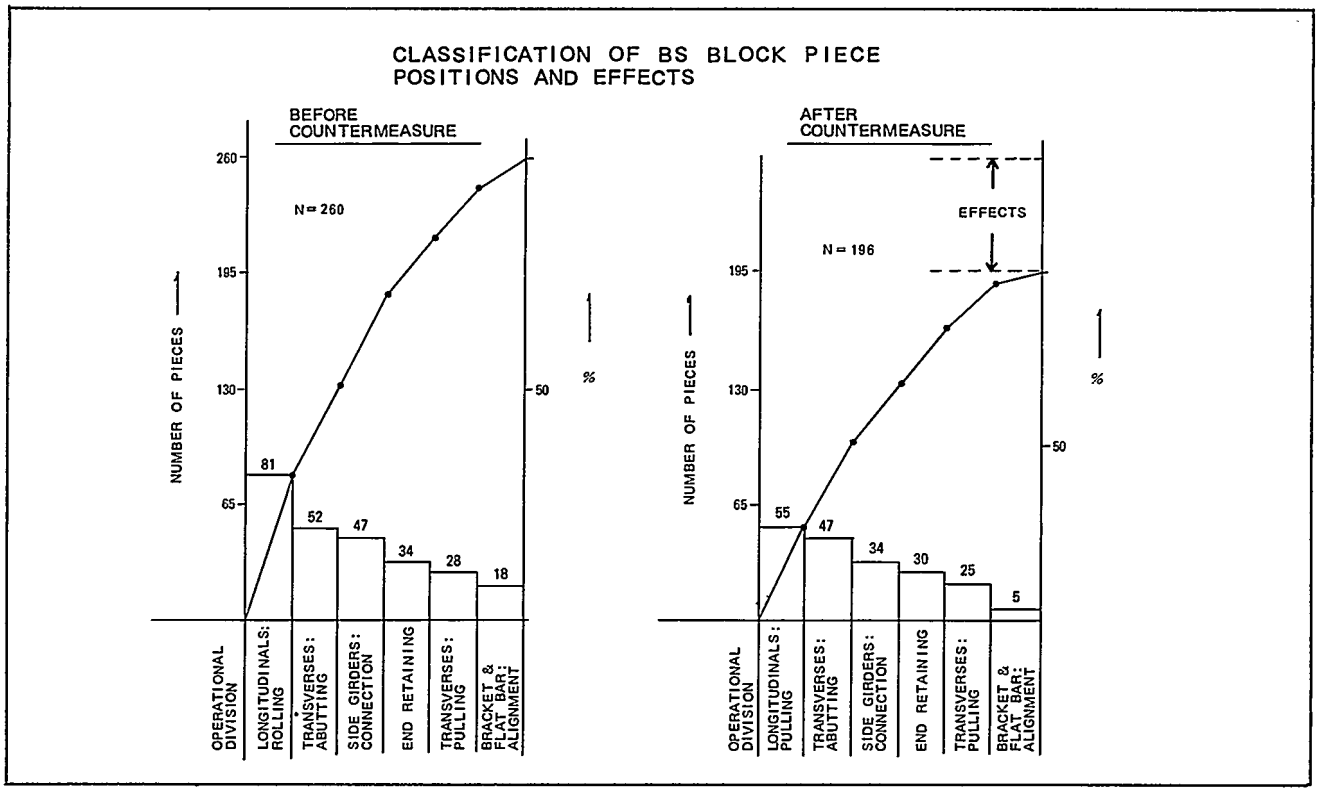
3. Analysis and Countermeasures

At a Group meeting, a Fishbone Diagram was prepared. It aided the Group in determining that the items that should receive the most weight. They were: Improvement and Use of Jigs and Operations (performing work) After Thinking. Accordingly, a review was made of the jigs and tools so far used and improvements were made to suit current work. At the same, how they were being used was reviewed and improvements in the manner of their use were made accordingly.

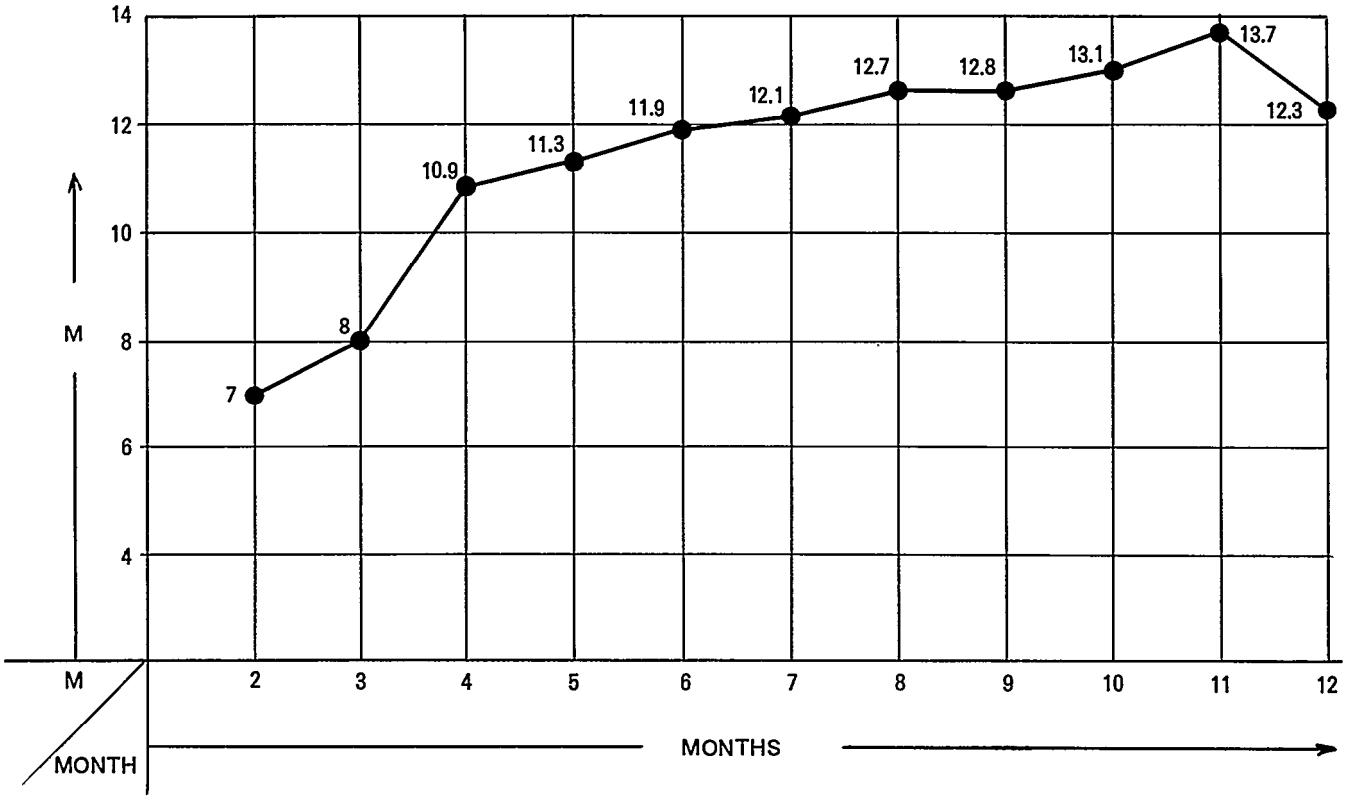
4. Effects and the Future

As a direct result of Group members concentrating on the problems identified, a reduction of 25% was achieved for bottom shell blocks. By the fifth month, the target of 12 meters/temporary piece was achieved. Simultaneously, efficiency improved. This latter improvement is attributed to the review of usage of jigs and tools which disclosed the smartest ways for their use which subsequently were made standards for all members to exploit. In the future jigs and tools and their use will be constantly reviewed so that they are always optimum for current work circumstances.


KNOWLEDGE, TECHNICAL SKILL
OPERATIONAL METHOD
KNOW ESSENTIALS OF BLOCKS
KNOWLEDGE ON JIGS AND TOOLS
POSITION OF TEMPORARY PIECES
OPERATION WITH WARPING TAKEN INTO CONSIDERATIONS
ADVANCE CHECK
MANNER OF PLACING BLOCKS
TACK WELD SEQUENCE
METHOD OF MATERIALS ARRANGEMENT
◎ EXPANDED SCOPE OF USE OF JIGS & TOOLS AND THE LIKE
METHOD FOR CUT-BACK OF THE NUMBER OF TEMPORARY INSTALLED PIECES
LOCATIONS OF JIGS AND TOOLS ARE PLACED
CLARIFICATION OF OPERATIONAL INSTRUCTIONS
REPORT ON ACTUALS AND PURSUIT OF CAUSES
ENSURING OF TOOLS REQUIRED
◎ IMPROVEMENT AND USE OF JIGS
ADJUSTMENT OF TOOLS AND THE LIKE
◎ OPERATION AFTER THINKING = TACKLE POSITIVELY
CONFIRMATION OF PIECE WELDING
THOROUGHGOING CONTACT ON LOCATIONS OF NONCONFORMITY
MANAGEMENT SYSTEM
OPERATOR


CLASSIFICATION OF BS BLOCK PIECE POSITIONS AND EFFECTS
BEFORE COUNTERMEASURE
N = 260
NUMBER OF PIECES
260
195
130
65
81
52
47
34
28
18
50
%
OPERATIONAL DIVISION
LONGITUDINALS: ROLLING
TRANSVERSES: ABUTTING
SIDE GIRDERS: CONNECTION
END RETAINING
TRANSVERSES: PULLING
BRACKET & FLAT BAR: ALIGNMENT
AFTER COUNTERMEASURE
EFFECTS
N = 196
NUMBER OF PIECES
195
130
65
55
47
34
30
25
5
50
%
OPERATIONAL DIVISION
LONGITUDINALS: PULLING
TRANSVERSES: ABUTTING
SIDE GIRDERS: CONNECTION
END RETAINING
TRANSVERSES: PULLING
BRACKET & FLAT BAR: ALIGNMENT

ACTUAL GRAPH



Target: Improve Efficiency for Fitting Make-Up Pipe Pieces

1. Process Summary

Our Group is in charge of the processes for landing through completion of outfit units insofar as connections are required to complete pipe systems.

2. Target Selection and Setting

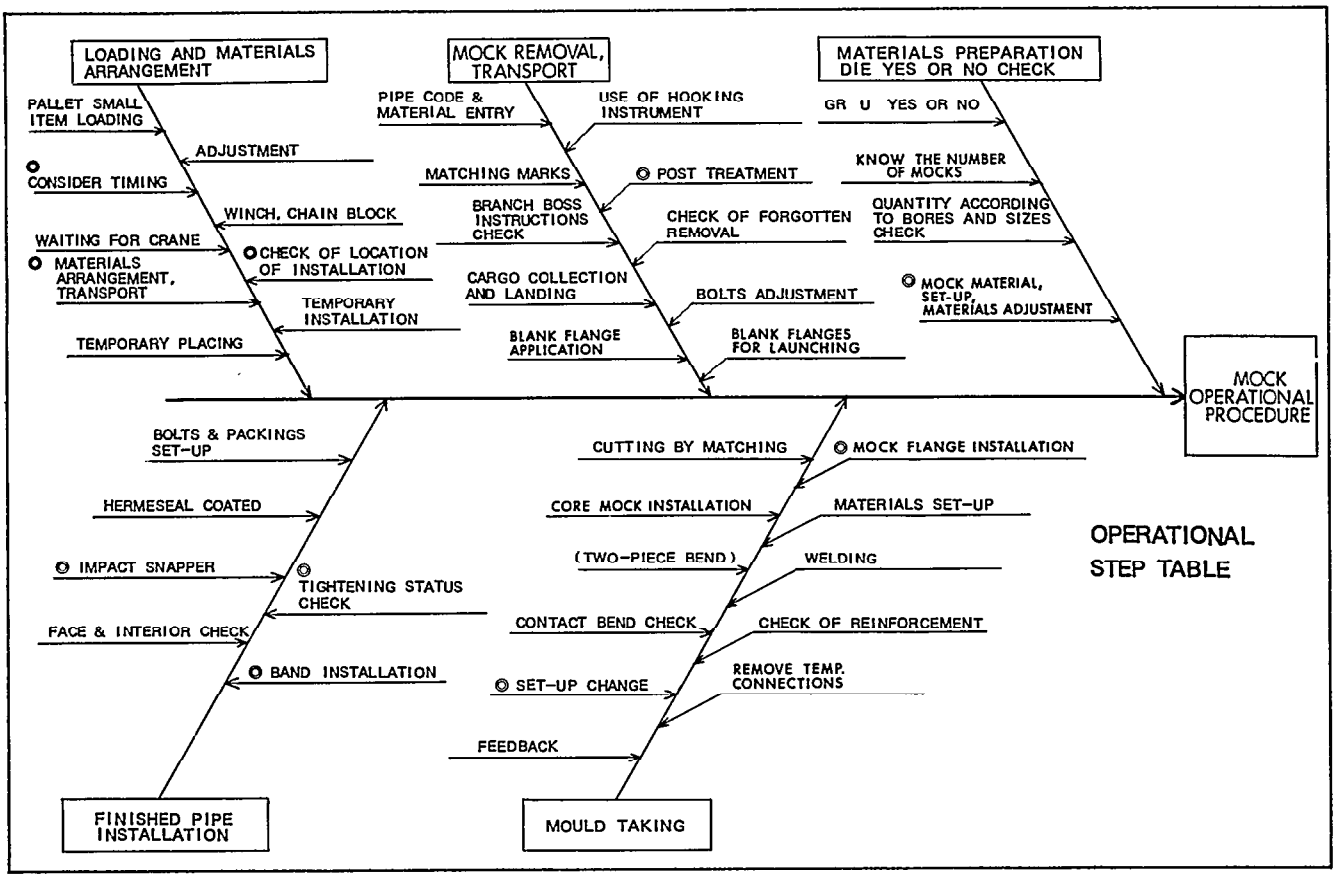
Keeping in mind the Section's theme, "Reduce Lost Man-Hours", all members of tour Group carried a man-hour analysis for our entire operations. As a result we found that man-hours associated with make-up pipe pieces account for the greatest proportion. We selected our target accordingly. As for a target value, results from the past were investigated and it was found that 2.40 man-hours (H) were used per make-up pipe piece. We then established 2.16 H, a 10% reduction, as a challenge.

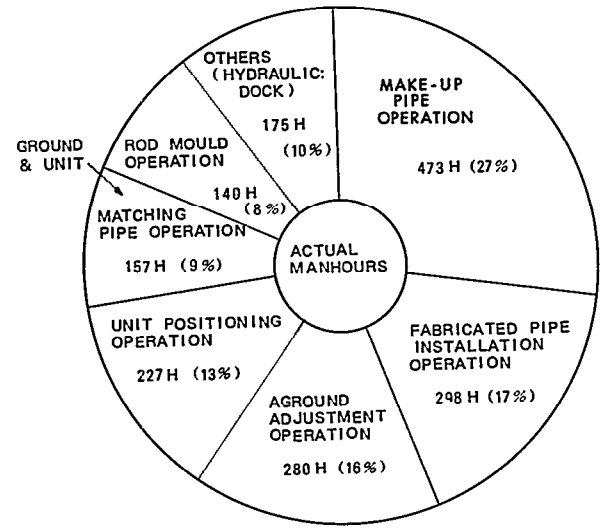
3. Analysis and Countermeasures

The Group divided our operation and prepared a table of operational steps. Among all parts of the operation, finishing a make-up pipe piece and preparing a mock-up of the piece account for 35% and 31% of our man-hours respectively. Our studies produced agreement that there will differences because of different manners of operation by different individuals and that time is consumed in installing and removing temporary bolts. Countermeasures were established.

4.Effects and the Future

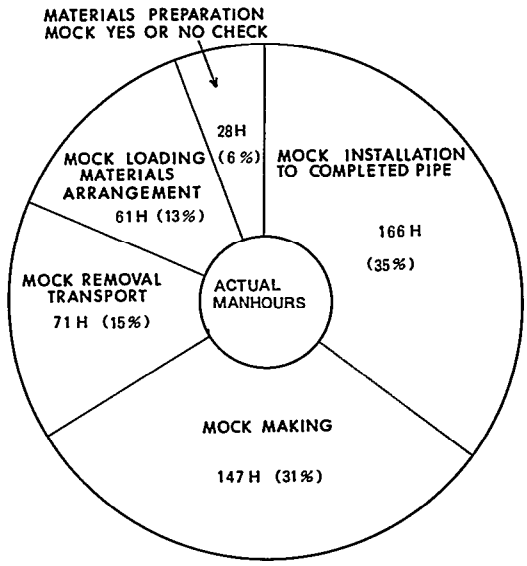
Now, as soon as blocks outfit units are landed on block or on board, and as soon as blocks are joined to create grand blocks or are erected, mocks are made and requests for manufacture of make-up pieces are submitted. This new emphasis provides quicker availability and installation of make-up pipe pieces. As the application of blank flanges before launching is just about totally eliminated, the target value was achieved. Our operation manual will be constantly reviewed and improved to ensure that it is optimum for current work. In order to minimize the time required for receiving a pallet and checking and arranging its contents, mock-up dates required by the Pipe Piece Manufacturing Shop in order to meet pallet need dates, will continue to be emphasized. In other words, every effort will be aplied to insure that make-up pieces are fitted as early as possible.





THE CIRCULAR GRAPH REPRESENTS PROPORTIONS OF PAST ACTUAL AVERAGE MANHOURS AND MANHOURS ACCORDING TO EACH OPERATION.

ACTUAL AVERAGE MANHOURS
1750 H



THE CIRCULAR GRAPH REPRESENTS PROPORTION OF ACTUAL AVERAGE MAN-HOURS AND MAN-HOURS ACCORDING TO EACH OPERATION RELATIVE TO MAKE-UP PIPE PIECE OPERATION.

ACTUAL AVERAGE MANHOURS
473 H

◎POINTS AT ISSUE UNDER CHALLENGE

1. DIFFERENCE IN OPERATIONAL PROCEDURES EXISTS.
   1) ALL BOLT HOLES OF MOCK FLANGE ARE USED AND TIGHTENED.
   2) GAS OPERATION DUE TO CUT BY MATCHING IS PLENTY.
   3) FULL WELDING IS PERFORMED.
   4) MOCK FLANGE DOWELLS ARE FLOWN. (WARPING OCCURS, HOT)

2. MAINTENANCE OF BOLTS AFTER REMOVAL IS FAULTY.

<COUNTERMEASURES >

1) −① PERFORM TIGHTENING WITH ONE HALF OF THE NUMBER OF MOCK FLANGE BOLT HOLES.
   −② AVOID PRACTICING OF STRAIGHT JOINT BUT, USE WASTE MATERIAL AFTER LAP JOINT.
   −③ MANAGE TO REDUCE TIME THROUGH PRACTICE OF TAP WELD.
   −④ UTILIZE ANGLE PIECE, ETC.

2) DURING MOCK REMOVAL OPERATION UTILIZE SMALL ITEMS CONTAINER, ETC., AND KEEP BOLTS AT MAINTAINED AT SPECIFIED LOCATION.

◎EFFECTS

	S. 2781/2794	S. 2795		BREAKDOWN
TEMPORARY SERVICE PIPE	473 H	423 H	50 H	MOCK TAKING 16H; LOADING, MATERIALS ARRANGEMENT 15H
OPERATION MANHOURS PER MOCK	2.4 H/PC	2.14 H/PC	0.26 H	BLANK FLANGE INSTALLATION FOR LAUNCHING 8H; OTHERS 11H

Target: Improve Observance of Compartment Hot-Work Scheduled Completion Dates

1. Process Summary

Our Group is in charge of on-board installation, adjustment, and operation of machinery outside of the machinery space (winches, cranes, etc.)

2. Target Selection

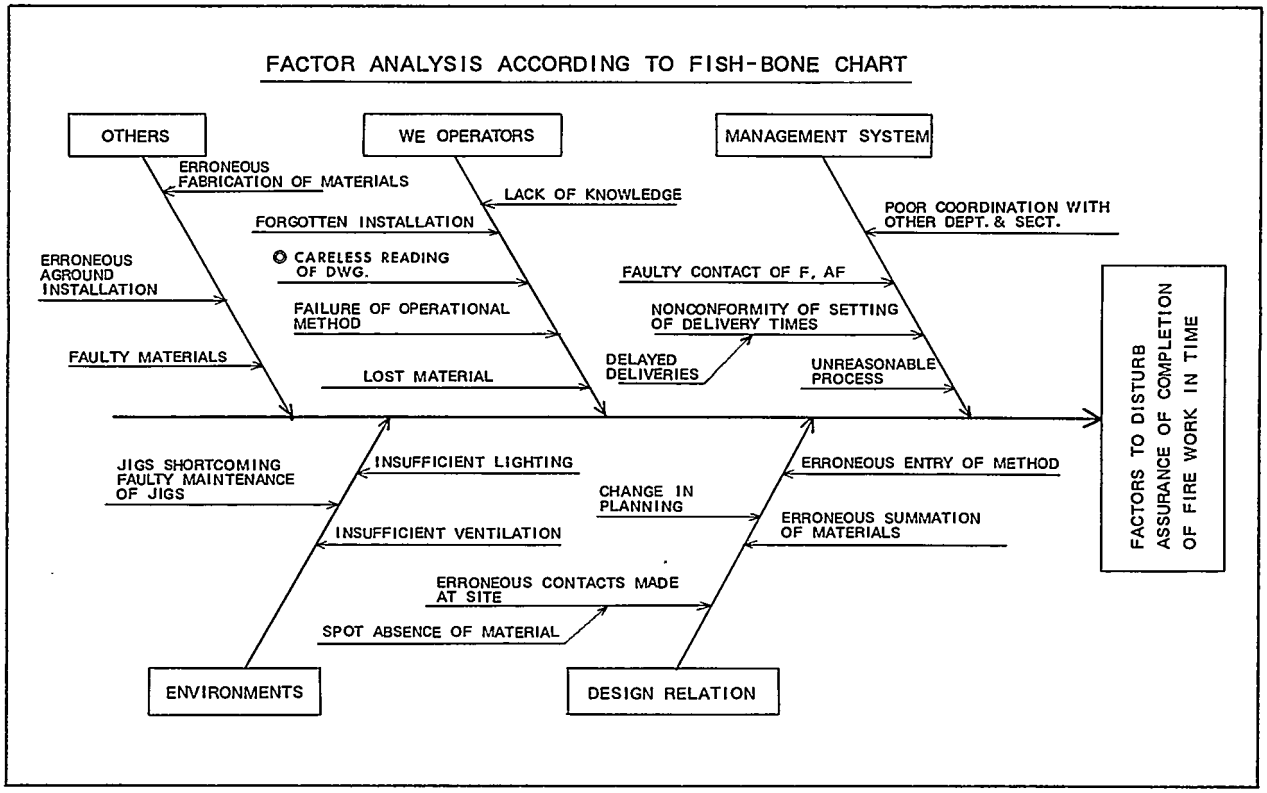
Our Group's theme is consistent with our Section's, "Reduce Lost Work". We established as a challenge "Improve Observance of Compartment Hot-Work Scheduled Completion Dates" for better assuring that no hot work would be performed after other work, such as painting, started.

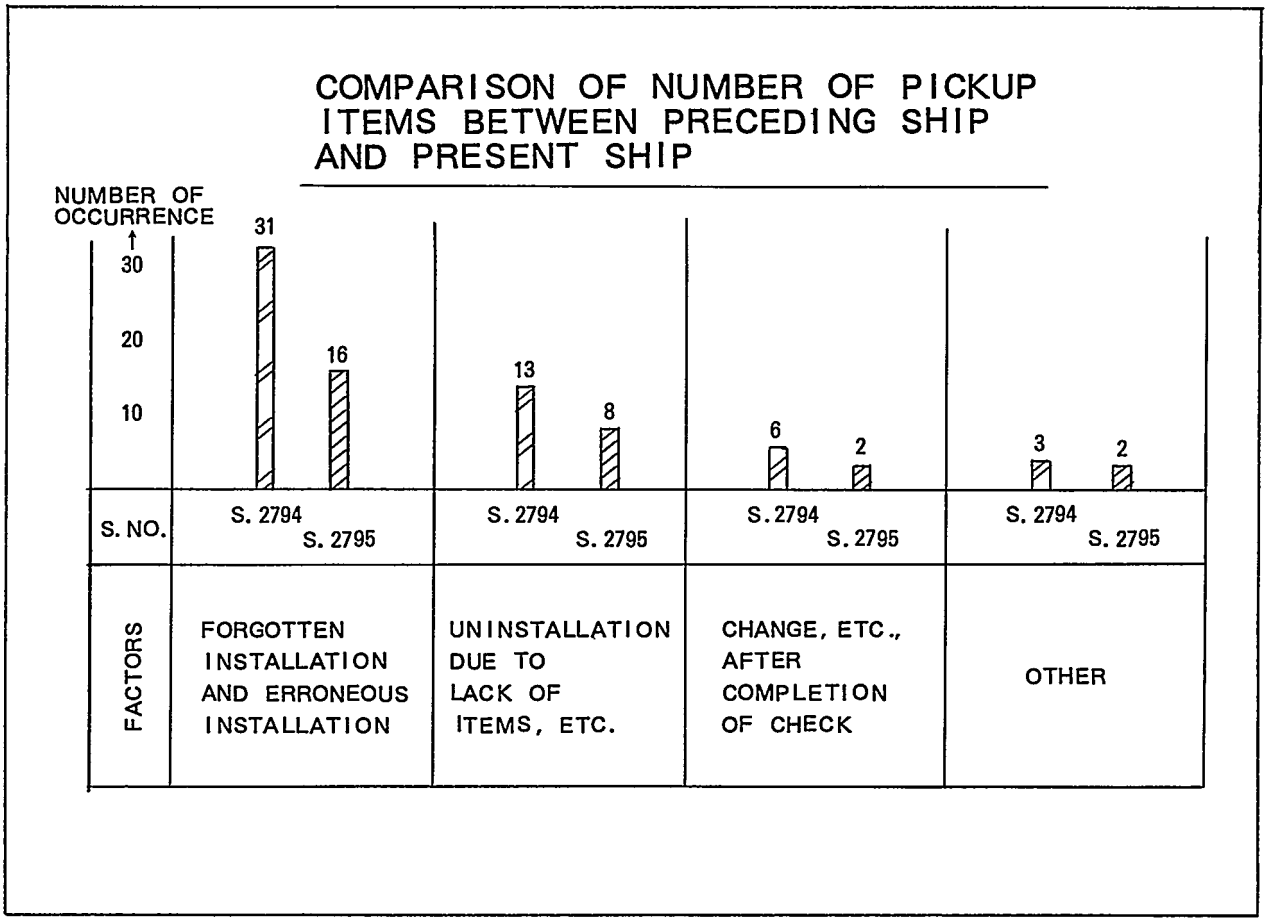
3. Analysis and Countermeasures

Problems were discussed by Group Members and a Fishbone Diagram was prepared. Based on the diagram, we decided that "Careless Reading of Drawings" was the problem to be given top weight. The number of "pick-up" items obtained from the history of the preceding ship. Each was studied and the following countermeasures were put into practice: (a) Before work is performed, work instructions, drawings, etc., are studied thoroughly. Immediately after completion of work, checks are made with an assistant foreman present. (b) When each material pallet arrives, it is carefully checked to assure that it is complete per its material list (MLF). Notices of missing materials are handled promptly. (c) Performance from each preceding ship will be studied and kept in mind before work starts. Also, schedules are now installed in each compartment advising concerned people, especially painters, of expected completions of pick-up items and hot work.

4. Effects and the Future

As a result of the above measures, the number of pick-up items reduced from 53 in the preceding ship to 28. At the same time, the efficiency for on-board fitting operations improved by 8.5%. In the future we will continue to challenge the same theme until pick-up items are completely eliminated.


FACTOR ANALYSIS ACCORDING TO FISH-BONE CHART
OTHERS
WE OPERATORS
MANAGEMENT SYSTEM
ERRONEOUS FABRICATION OF MATERIALS
LACK OF KNOWLEDGE
POOR COORDINATION WITH OTHER DEPT. & SECT.
FORGOTTEN INSTALLATION
ERRONEOUS AGROUND INSTALLATION
CARELESS READING OF DWG.
FAULTY CONTACT OF F, AF
FAILURE OF OPERATIONAL METHOD
NONCONFORMITY OF SETTING OF DELIVERY TIMES
FAULTY MATERIALS
LOST MATERIAL
DELAYED DELIVERIES
UNREASONABLE PROCESS
FACTORS TO DISTURB ASSURANCE OF COMPLETION OF FIRE WORK IN TIME
JIGS SHORTCOMING FAULTY MAINTENANCE OF JIGS
INSUFFICIENT LIGHTING
ERRONEOUS ENTRY OF METHOD
CHANGE IN PLANNING
ERRONEOUS SUMMATION OF MATERIALS
INSUFFICIENT VENTILATION
ERRONEOUS CONTACTS MADE AT SITE
SPOT ABSENCE OF MATERIAL
ENVIRONMENTS
DESIGN RELATION


COMPARISON OF NUMBER OF PICKUP ITEMS BETWEEN PRECEDING SHIP AND PRESENT SHIP
NUMBER OF OCCURRENCE
30
20
10
31
16
13
8
6
2
3
2
S. NO.
S. 2794
S. 2795
S. 2794
S. 2795
S. 2794
S. 2795
S. 2794
S. 2795
FACTORS
FORGOTTEN INSTALLATION AND ERRONEOUS INSTALLATION
UNINSTALLATION DUE TO LACK OF ITEMS, ETC.
CHANGE, ETC., AFTER COMPLETION OF CHECK
OTHER

Target: Perform Deck Covering Work Within Budgeted Man-Hours

1. Operation Summary

Our Group applies composition material and tile to decks of accommodation spaces.

2. Selection and Setting a Target

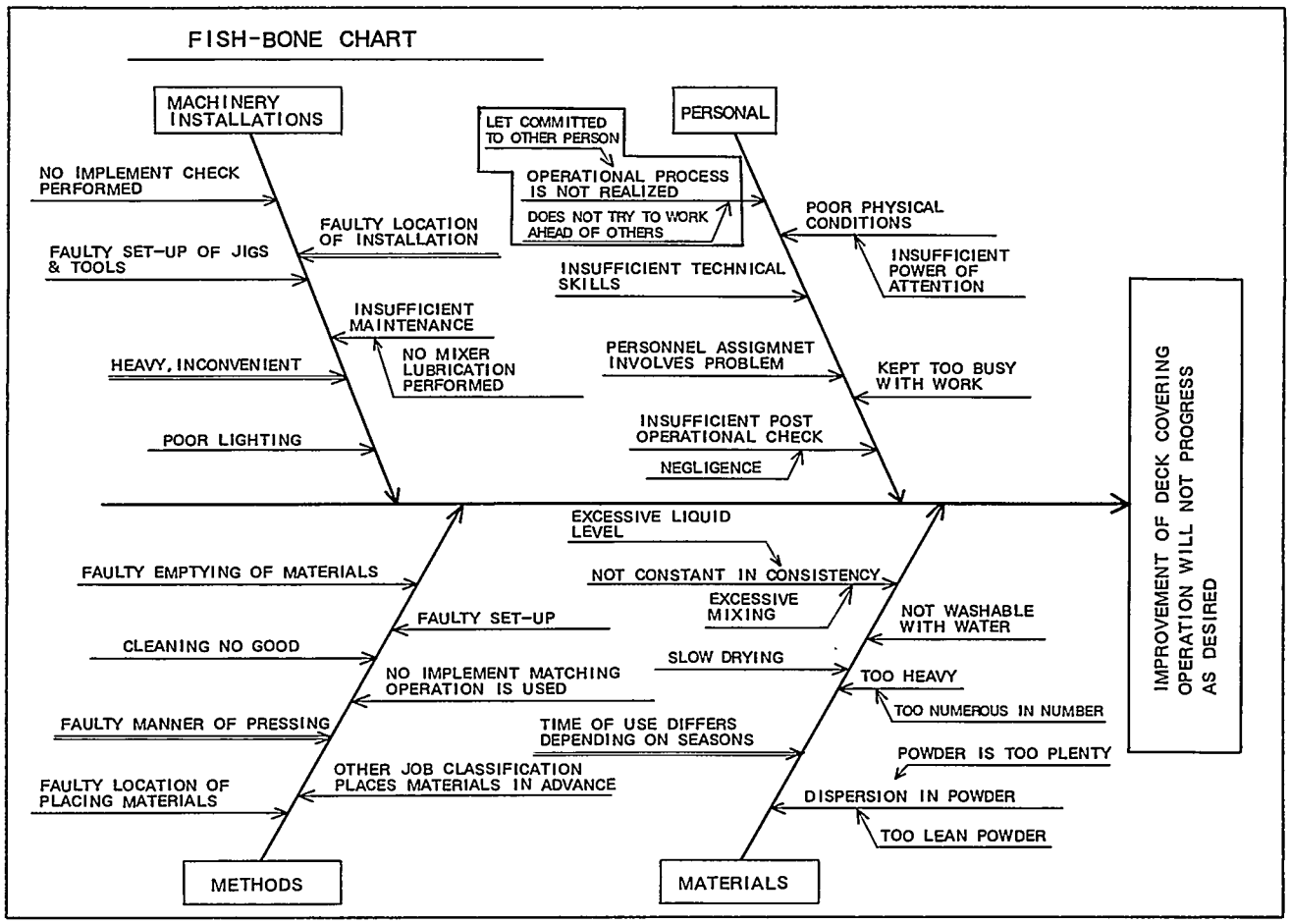
Our Group selected “Observing Budgeted Man-Hours” in line with our Section’s theme, “Observe Each Ship’s Budgeted Man-Hours”. Based on a review of our past performance, we decided to set 0.45 man-hours/square meter as a challenge.

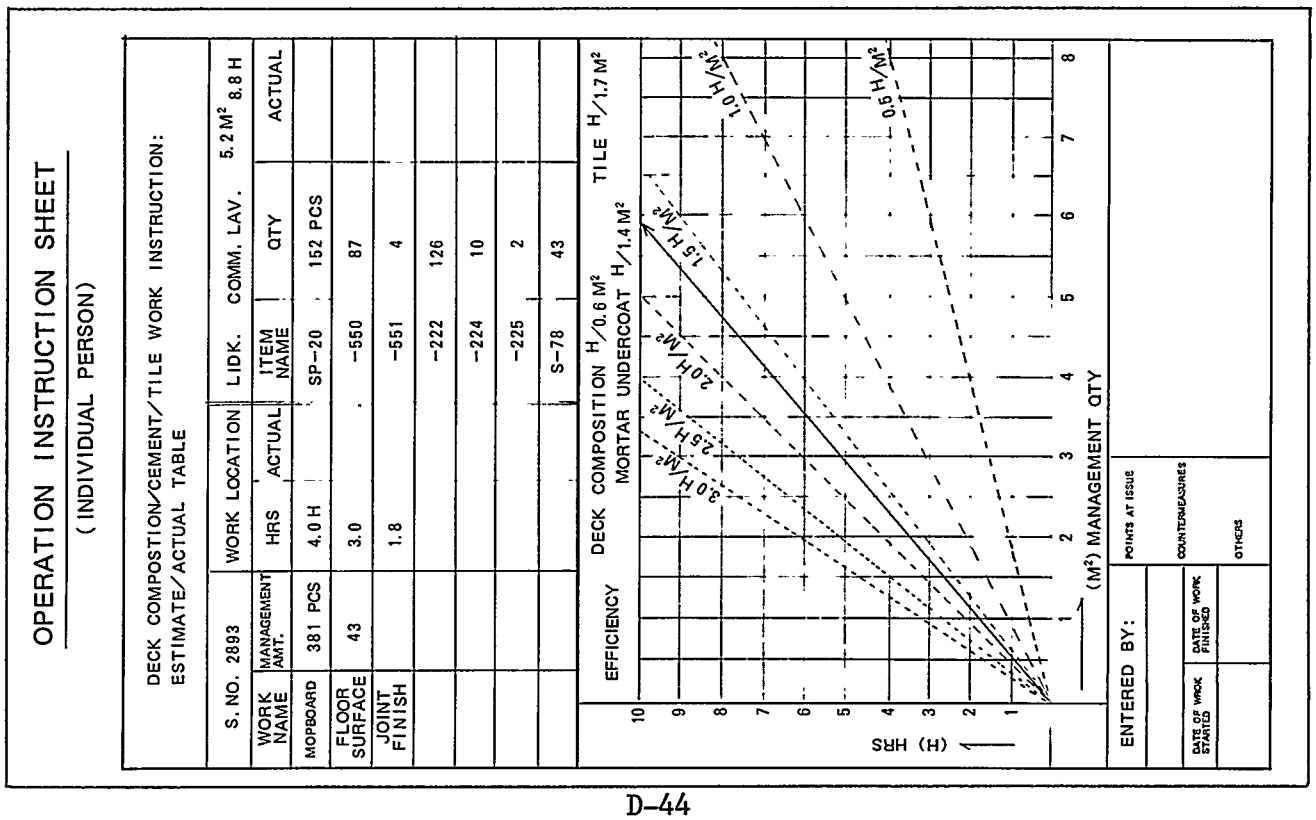
3. Analysis and Countermeasures

At a Group meeting, factors that impede improvement were analyzed with the aid of a Fishbone Diagram. It was found that in many cases we performed work with inadequate planning. Hence, it was decided that man-hours will be allocated by individual compartment to facilitate control. Also, it was decided to issue an Operation Instruction Sheet to each Group member.

4. Effects and the Future

As a result of the countermeasures, improvements were obtained gradually. But, the following problems continue: (a) Material movements are frequent. Movement should be made by pallets; jigs should be developed for lifting cement materials to the top of power mixers. (b) Adhesive materials clog hoses. A hose cleaning system is required. (c) Methods for applying insulation materials to bulkheads and overheads are not uniform. All application methods are being studied and the most effective will be used.


FISH-BONE CHART
MACHINERY INSTALLATIONS
NO IMPLEMENT CHECK PERFORMED
FAULTY SET-UP OF JIGS & TOOLS
FAULTY LOCATION OF INSTALLATION
INSUFFICIENT MAINTENANCE
NO MIXER LUBRICATION PERFORMED
HEAVY, INCONVENIENT
POOR LIGHTING
PERSONAL
LET COMMITTED TO OTHER PERSON
OPERATIONAL PROCESS IS NOT REALIZED
DOES NOT TRY TO WORK AHEAD OF OTHERS
POOR PHYSICAL CONDITIONS
INSUFFICIENT POWER OF ATTENTION
INSUFFICIENT TECHNICAL SKILLS
PERSONNEL ASSIGMNET INVOLVES PROBLEM
KEPT TOO BUSY WITH WORK
INSUFFICIENT POST OPERATIONAL CHECK
NEGLIGENCE
EXCESSIVE LIQUID LEVEL
IMPROVEMENT OF DECK COVERING OPERATION WILL NOT PROGRESS AS DESIRED
FAULTY EMPTYING OF MATERIALS
FAULTY SET-UP
CLEANING NO GOOD
NO IMPLEMENT MATCHING OPERATION IS USED
FAULTY MANNER OF PRESSING
OTHER JOB CLASSIFICATION PLACES MATERIALS IN ADVANCE
FAULTY LOCATION OF PLACING MATERIALS
METHODS
NOT CONSTANT IN CONSISTENCY
EXCESSIVE MIXING
NOT WASHABLE WITH WATER
SLOW DRYING
TOO HEAVY
TOO NUMEROUS IN NUMBER
TIME OF USE DIFFERS DEPENDING ON SEASONS
POWDER IS TOO PLENTY
DISPERSION IN POWDER
TOO LEAN POWDER
MATERIALS


OPERATION INSTRUCTION SHEET
(INDIVIDUAL PERSON)
DECK COMPOSTION/CEMENT/TILE WORK INSTRUCTION:
ESTIMATE/ACTUAL TABLE
S. NO. 2893
WORK NAME
MANAGEMENT AMT.
WORK LOCATION
HRS
ACTUAL
LIDK. COMM. LAV. 5.2 M² 8.8 H
ITEM NAME
QTY
ACTUAL
MOPBOARD 381 PCS 4.0 H SP-20 152 PCS
FLOOR SURFACE 43 3.0 -550 87
JOINT FINISH 1.8 -551 4
-222 126
-224 10
-225 2
S-78 43
DECK COMPOSITION H/0.6 M² TILE H/1.7 M²
MORTAR UNDERCOAT H/1.4 M²
EFFICIENCY
1.0 H/M²
0.5 H/M²
1.5 H/M²
2.0 H/M²
2.5 H/M²
3.0 H/M²
(H) HRS
(M²) MANAGEMENT QTY
ENTERED BY:
POINTS AT ISSUE
COUNTERMEASURES
OTHERS
DATE OF WORK STARTED
DATE OF WORK FINISHED

CASE 16 (1 of 3) Accommodation Fitting Section

Target: Reduce Budgeted Man-Hours

1. Process Summary

Our Group performs carpenter work in accommodation spaces, i.e., application of insulation materials, installing lining boards, installing furniture, etc.

2. Selecting and Setting a Target

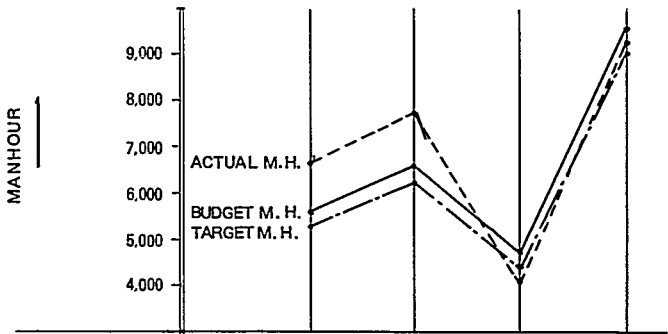
In the past our Group used to focus on only one part of our operations, set a target, and challenge it. Now, for the purpose of contributing to the realization of our Section's target, "Reduce Lost Time", we are addressing the overall man-hours assigned to us. We set a challenge for a 5% reduction.

3. Analysis and Countermeasures

At a Group meeting, we decided to sum lost time by various types of work in order to facilitate comparisons. Operation Analysis Check Sheets were prepared and assigned to Group members to make entries. The check sheets addressed: (a) preparatory operations, (b) principal operations, (c) lost time, (d) incidental work, and (e) time allowed to the nearest minute. Analysis showed that cutting operations (trimming materials) accounted for the greatest lost time, 22%. Countermeasures were established. Panels are now finish cut before they are landed on board. As compared to before, they are now cut slightly undersized and a wider molding is used to cover the edges after they are fitted. Openings for electric wiring are also cut before panels are landed on board and marked to facilitate on-board cable pulling. Improved feedback is now achieving more pertinent attention from design, fabrication subcontractors, etc.

4. Effects and the Future

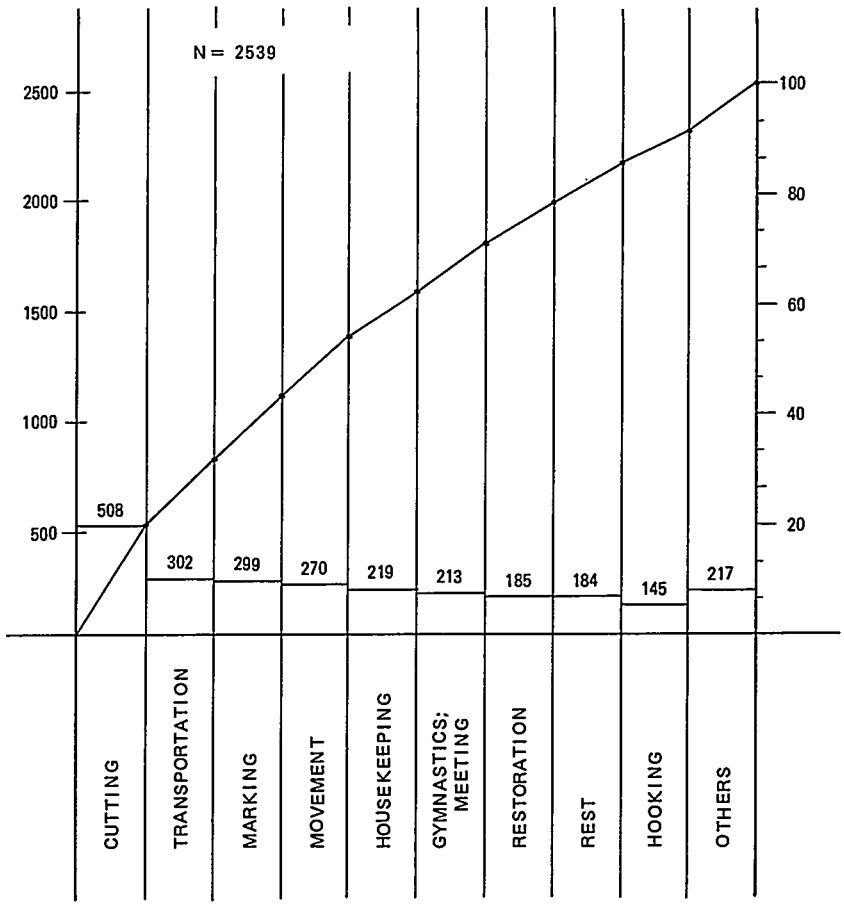
On the third vessel built after our check sheet system started, we just about achieved our target. In addition to continuing checks of our own work, we plan to do more to arrange materials before work starts, provide better distribution and transportation, respond faster to damage incidents, etc., all of which are intended to further reduce man-hours.



S. NO.	2741	2742	2784	2770
BUDGET M.H.	5650H	6642H	4550H	9550H
TARGET M.H.	5367H	6310H	4323H	9075H
ACTUAL M.H.	6800H	7895H	4265H	9171H

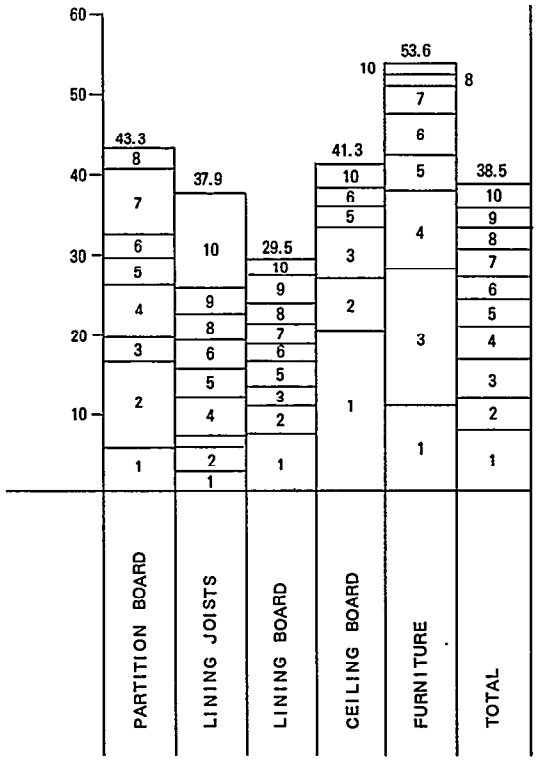
TABULATED FACTORS OF LOSS

CLASSIFIED ITEMS	LOST TIME (MIN)	LOST TIME (%)
CUTTING	508	22.0
TRANSPORTATION	302	11.9
MARKING	299	11.8
MOVEMENT	270	10.6
HOUSEKEEPING	219	8.6
GYMNASTICS; MEETING	213	8.4
RESTORATION	185	7.3
REST	181	7.1
HOOKING	145	5.7
OTHERS	217	8.6
TOTAL	2539	100.0



CHECK SHEET SUMMATION; LOSS WORK, LOSS TIME ACCORDING TO EACH OPERATION

NAME OF OPERATION	PARTITION BOARD		LINING JOISTS		LINING BOARD		CEILING BOARD		FURNITURE		TOTAL	
OPERATION TIME	1245 MIN		1440 MIN		2400 MIN		480 MIN		1020 MIN		6585 MIN	
LOSS TIME	MIN	%	MIN	%	MIN	%	MIN	%	MIN	%	MIN	%
1. CUTTING	70	5.6	50	3.5	175	7.3	100	20.8	113	11.0	508	7.7
2. TRANSPORTATION	144	11.6	30	2.1	98	4.1	30	6.3			302	4.6
3. MARKING	30	2.4	15	1.0	50	2.1	30	6.3	174	17.4	299	4.6
4. MOVEMENT	85	6.8	85	5.9					100	9.8	270	4.1
5. HOUSEKEEPING	40	3.2	45	3.1	80	3.3	10	2.1	44	4.3	219	3.3
6. GYMNASTICS; MEETING	36	2.9	50	3.5	63	2.6	13	2.7	51	5.0	213	3.2
7. RESTORATION	95	7.6			45	1.9			45	4.4	185	2.8
8. REST	40	3.2	50	3.5	66	2.8	15	3.1	10	1.0	181	2.7
9. HOOKING			60	4.2	85	3.5					145	2.2
10. OTHERS			160	11.1	47	1.9			10	1.0	217	3.3
TOTAL	540	43.3	545	37.9	709	29.5	198	41.3	547	53.6	2,539	38.5



CASE 17 (1 of 2) Painting Section

Target: Reduce Budgeted Man-Hours

1. Process Summary

Our Group paints tank holds and upper-deck spaces.

2. Selecting and Setting a Target

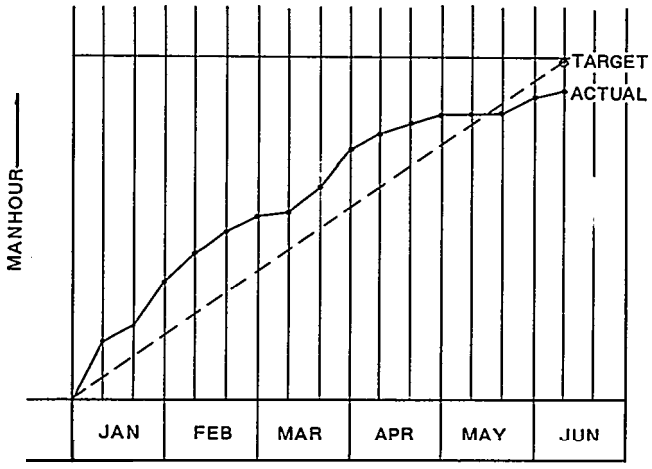
At our Group meeting we decided as a challenge to reduce budgeted man-hours for all compartments by 10%. The reason for addressing all compartments, was to involve all members of our Group.

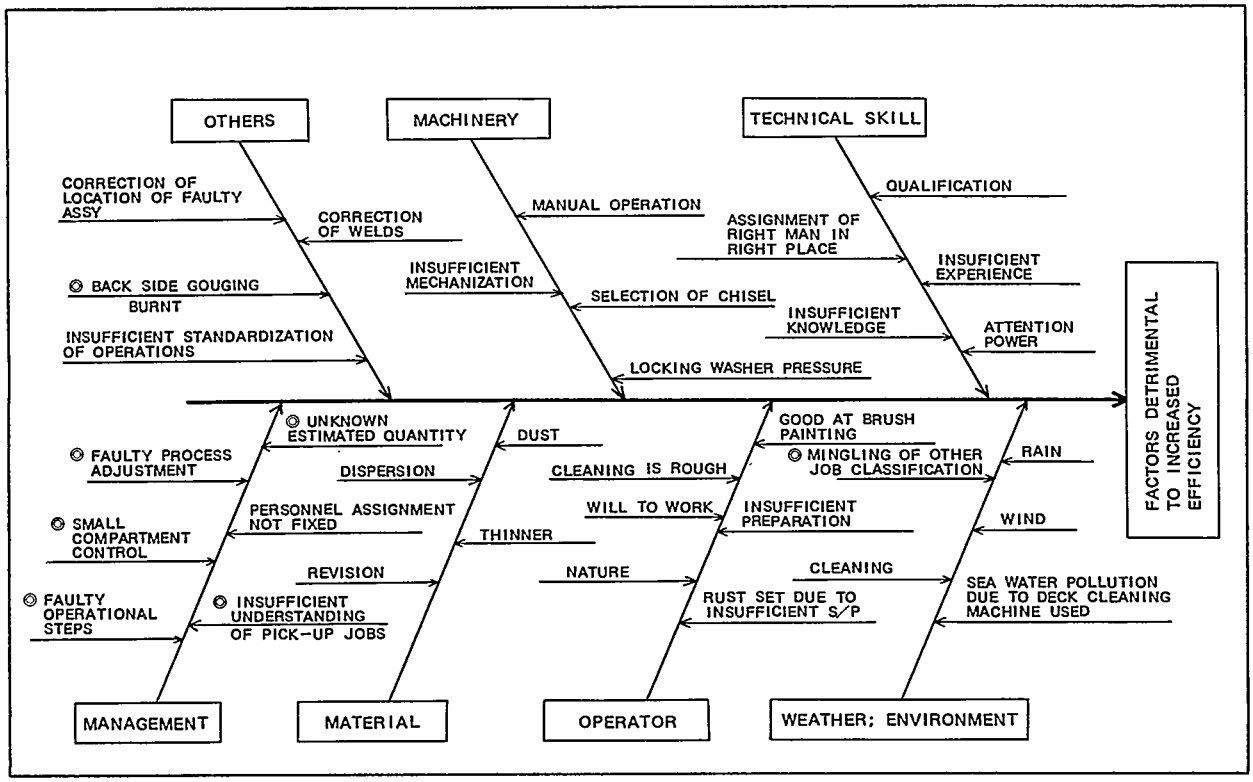
3. Analysis and Countermeasures

We reviewed our operations for work in previous ships and made notes of what could have been done more efficiently. Our discussions then indicated that we should apportion our budgeted funds and scheduled time compartment by compartment. Discussions also indicated that we should do an advance check of pick-up for work which other groups are responsible, particularly hot work, as one way to minimize painting rework. Also, we decided that we should standardize our operations and be alert to change the standards when improved methods come along and when the nature of work changes. Thus, we now are: (a) perfecting compartment by compartment budget and schedule control, (b) checking for other groups' pick-up items before painting starts, (c) painting a tank and the deck of the compartment above at the same time (this helps insure that no hot work is taking place above when we are working below), and (d) changing the timing for removal of scaffolding within tanks and establishing better methods for repainting damaged surfaces.

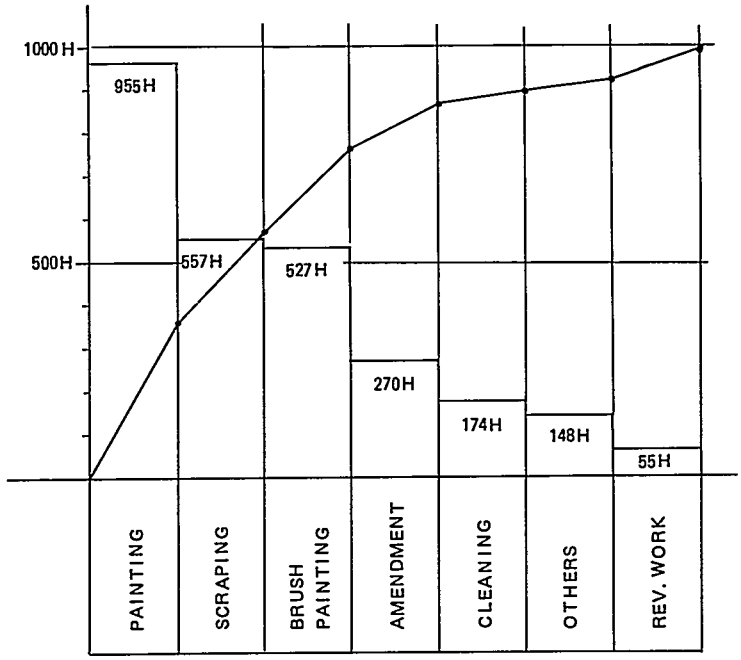
4. Effects and the Future

As a result of the countermeasures, our target was achieved. But, for more improvement it is necessary for us to: (a) work continuously, i.e., without interruptions, (b) institute production-line operations (virtual work flows), (c) collaborate more with groups performing other types of work, particularly hot work, and (d) continue to refine our budget and schedule control on a compartment by compartment basis.





AN EXAMPLE OF BREAKDOWN OF UPPER DECK OPERATIONS



Target: Improve Conformance With Drawing Issue Dates

1. Process Summary

Our Group performs detail design for engine-room piping.

2. Selecting and Setting a Target

To say the least, delays in issuing drawings in the past annoyed others. Improving our compliance with drawing issue dates is becoming more difficult because the current market is for more complicated ships of different types and for diverse end products other than ships. Thus, our Group decided to challenge compliance with drawing issue dates. The parameter we selected to monitor drawing is the average days late over a two week period. Since our performance was 1.2 days/2-weeks. We set our target at 1.0 days/2-weeks, a proposed improvement of 16.7%.

3. Analysis and Countermeasures

Our Group selected themes that all members would understand and identified problems that could be resolved in a reasonable length of time. The most effective countermeasure was scheduling design work in more detail and organizing schedules per individuals. Check off was formally accomplished every two weeks. Specific countermeasures were immediately applied to delays noted during check off and a separate accounting was made of each individuals effect

4. Effects and the Future

As a result of updating and summarizing by individuals *every* two weeks, we achieved 1.05 days/2-weeks in the first year, i.e. , (29 days total delay)/ (55 design weeks), for a 12.5% improvement. Although we did not meet our target, we did effect a significant improvement and were able to identify four specific cases that had the most detrimental impact. As the experience was very rewarding, their were no complaints from those scheduled to receive our drawings, we will continue to refine our approach with special attention to cases similar to the four cases which prevented us from reaching our target.

Target: Reduce the Number of Elbows in Pipe Systems

1. Process Summary

Our Group performs detail design for engine-room piping.

2. Selecting and Setting a Target

Elimination of elbows in pipe systems is a universally recognized way to improve productivity during pipe piece manufacturing. Our Group recognized that to conform with our Section's policy for productive design details, we must be more vigorous and apply a target which challenges us to eliminate separate elbow fittings by achieving a greater percentage of straight pipe lengths (eliminating unnecessary bends)-and by substituting pipe bends-for elbows. Since the past similar-powered ship employed 828 elbows, our Group established 300 less as our goal, i.e., a decrease of 36%.

3. Analysis and Countermeasures

Our Group talked about various methods to effect bends without elbows. The Group confirmed that when bends are necessary they would specify bends per the following priority sequence: normal pipe bending, high-frequency bending, and use of elbows. It was agreed also, to obtain cost comparisons between high-frequency bending and elbows which were to be disseminated to all members. Other related subjects were reviewed, e.g., high-frequency bending data and the poli–lined pipe fabrication standard. Also, the Group suggested special screening to take place when pipe-detail sketches are prepared to pick up any elbows that could be replaced by high-frequency bends.

4. Effects and the Future

As a consequence of our Group's concerted effort, we achieved a cutback of 315 elbows, i.e., a 38% reduction which slightly exceeded our target. Also, due to increased pertinent knowledge within the Group and a revised fabrication standard, we now have potential to continue to improve in future ships.

NOMINAL DIA	SNO. 2914 ACTUAL			SNO. 2929 TARGET			SNO. 2929 ACTUAL		
	45° ELBOW	90° ELBOW	TOTAL	45° ELBOW	90° ELBOW	TOTAL	45° ELBOW	90° ELBOW	TOTAL
25	0	32	32	0	0	0	0	0	0
32	0	32	32	0	20	20	0	3	3
40	0	68	68	0	50	50	0	55	55
50	15	155	170	10	100	110	2	38	40
65	6	91	97	5	60	65	6	38	44
80	1	52	53	0	35	35	2	16	18
100	6	50	56	5	30	35	5	51	56
125	23	65	88	15	45	60	15	36	51
150	9	50	59	5	35	40	7	19	26
200	10	57	67	6	40	46	3	11	14
250	15	50	65	10	35	45	16	64	80
300	2	16	18	0	10	10	10	19	29
350	0	0	0	0	0	0	15	11	26
400	1	0	1	0	0	0	22	33	55
450	0	0	0	0	0	0	0	0	0
500	2	12	14	0	5	5	0	0	0
550	2	6	8	0	4	4	5	6	11
600									
650							2	0	2
700									
750							1	2	3
TOTAL	92	736	828	56	469	525	111	402	513

CASE 20 (1 of 1) Design Department

Target: Cut Back Design Man-Hours

1. Process Summary

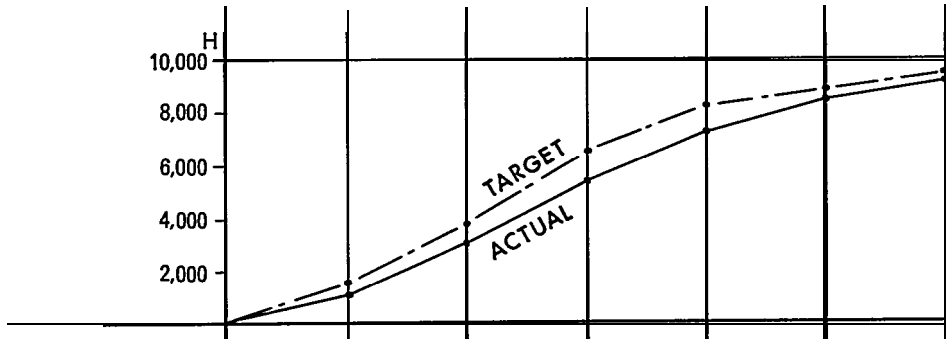
Our Group performs detail design for engine-room piping.

2. Selecting and Setting a Target

Our Group's operation is in accordance with a design procedure sheet. At a Group meeting, a member suggested that if certain factors cause nonconformance with the procedure sheet and cause subsequent rework, then those factors should be subjects for the Group to examine at the earliest opportunity. A cut back in man-hours should be planned through countermeasures to such problems. The Group agreed with the suggestion and proceeded accordingly. Also, the Group decided to clarify to what extent external factors, such as changes imposed upstream, cause man-hour expenditures in detail design so that we could maintain a realistic basis for man-hour comparisons. For a target value, as we were expending 1.9 man-hours/pipe piece, we set 1.7 man-hours/pipe piece, a 10.5% decrease.

4. Effects and the Future

By virtue of concerted effort by all Group members and the cooperation of related parties we achieved our target. We believe the that the experience will carry over and effect more improvement in future ships. In the process we found that man-hours spent due to external factors, accounted for about 10% of our total man-hour expenditure. We have all come to realize that early communications with each other and with those upstream and downstream who influence our work, are absolutely necessity. In the future we intend to review procedure sheets and our practices with the intention of making them more effective. Also, we will document our approach to problems so that they will serve as guides for approaching new problems and in this way, improve our Group's capacity to deal with problems.



	OCT	NOV	DEC	JAN	FEB	MAR
TARGET	1500 H	3900 H	6300 H	8100 H	8800 H	9300 H
ACTUAL	1326 H	3412 H	5524 H	7248 H	8753 H	9150 H